2018

Urban Gardens and Nutrition in Sioux Falls, SD

Austin Brynjulson
South Dakota State University

URBAN GARDENS AND NUTRITION IN SIOUX FALLS, SD

BY

AUSTIN BRYNJULSON

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Geography

South Dakota State University

2018

URBAN GARDENS AND NUTRITION IN SIOUX FALLS, SD

AUSTIN BRYNJULSON

This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science in Geography degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Jamie Spinney, Ph.D.
Thesis Advisor Date

Bob Watrel, Ph.D.
Head, Department of Geography Date

Kimchel Doerner, Ph.D.
Dean, Graduate School Date

This thesis is dedicated to my incredible wife Molly and my son Oliver.

ACKNOWLEDGEMENTS

Firstly, I would like to thank Dr. Trisha Jackson for her knowledge, ideas, support, and patience, in the process of writing of this paper. Her direction helped me over countless hurdles, and this entire project would not have been achieved without her.

I would like to thank my advisor Dr. Jamie Spinney for his much-appreciated guidance and support. A huge thank you also must go to the SDSU Geography department for supplying equipment that allowed for produce analysis. I would also like to thank Karin Woltjer Minnehaha County Master Gardener and Garden Coordinator, for her assistance in completing and distributing surveys to gardeners, and to Chris Morris and the Plant Science Laboratory at SDSU for their aid in laboratory analysis.

Additionally, I would like to thank my family and friends, for their encouragement, holding me accountable to my goals, and pushing me to work even when the task at hand seemed impossible.

Lastly, to Molly and Oliver, for their love, tolerance, support, and all they sacrificed to help me achieve this goal, and for teaching me how beautiful this world can be.

TABLE OF CONTENTS

ACRONYMS

BFRSS – Behavioral Risk Factor Surveillance System

BMI –Body Mass Index

CDC – Centers for Disease Control and Prevention

CHNA – Community Health Needs Assessment

CSA – Community Supported Agriculture

ERS – Economic Research Service

FAO - The Food and Agriculture Organization of the United Nations

HHS – United States Department of Health and Human Services

ICP-OES – Inductively Coupled Plasma – Optical Emission Spectrometer

MSA – Metropolitan Statistical Area

LB/LBS - Pounds

SDSU – South Dakota State University

USDA – United States Department of Agriculture

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

URBAN GARDENS AND NUTRITION IN SIOUX FALLS, SD

AUSTIN BRYNJULSON

2018

With the global population recently surpassing seven and a half billion, questions about feeding the population have emerged. In the past, increased demand for food was addressed through increasing intensification of land use and increasing the area of land under cultivation. Despite these efforts, food insecurity has increased for much of the population over this period, where, according to the USDA, in the U.S. 49.1 million people were food insecure in 2013. Food insecurity in this regard is the lack of access to sufficient, safe, and nutritious food at all times. While the complex global food system may be difficult to change, "ground up" solutions among local communities and households bring opportunity for success. Urban gardens offer a local and community-wide solution to help reduce the effects of food insecurity amongst households. This research explores the role of urban gardens as a tool to aid efforts in fighting food insecurity in Sioux Falls, SD, by examining the experiences of gardeners and how gardens have affected perceptions of food security and eating behaviors in their lives. Additionally, this research investigates the nutritional quality of urban garden produce as it compares to store-bought equivalents to reinforce the idea that increased nutritional quality means an individual who is more food secure. This research improves our understanding of the role community gardens play in providing local sources of nutrition by addressing one aspect of food insecurity, and how urban gardens in Sioux Falls, SD affect access to and consumption of nutritional food for the surrounding community.

Key Words: urban gardening, food security, obesity, food nutrition, community gardens

CHAPTER 1: INTRODUCTION

1.1 Global Population Increase and Urbanization

As of June 2017, the world's population reached just over seven and a half billion people and is expected to reach close to ten billion by 2050 (Department of Economic and Social Affairs 2017, 1). The majority of this growth is projected to take place in urban areas; a staggering notion considering that in the United States (U.S.) over 80% of the population already lives in urban areas (United States Census Bureau 2013). This projected urban growth has raised issues related to how we will sustainably feed the world's population in the future. In 2010, the National Research Council identified several constraints that need to be addressed in order to feed the population of the future. The constraints include: varied ability to balance production and consumption across regions; increased conversion of agricultural land to urban land; increased energy-intensive food production; and, increased use of food crops for biofuel production (National Research Council 2010, 59).

These constraints add complexity in identifying potential solutions for producing enough quality food for everyone. Furthermore, potential solutions will not likely focus solely on quantity of production, but on consumption patterns, types, and quality of foods produced, access to food, and costs at every level (Tilman et al. 2002, 675-676). As an example, increasing rates of obesity, especially childhood obesity, have affected food consumption and production patterns, which have led to the promotion of eating fresher, more nutritional produce in schools (Nguyen et al. 2015, 1453), avoiding eating food away from home (Altman et al. 2015, 1400), and developing models to assess healthy

and affordable food options (Primavesi et al. 2015, 827). These food system challenges vary by location, thus requiring location-specific solutions for states, counties, and cities.

1.2 Food Production and the Modern Food System

In the past, world populations responded to challenges of food production by agricultural intensification, a concept involving the production of more food with less land, and by increasing the area of cropland under production (Budiansky 2002, 581). Agricultural intensification increased quickly, aided by the Green Revolution of the 1940s to the late 1960s, and led to the creation of the industrial agricultural landscape we see today in the U.S.. This is a landscape focused on high-yield crop varieties, fields filled with monocultures, improved irrigation, intensive mechanization, advances in plant breeding and genetics, and extensive application of synthetic chemicals for fertilizers and pest and weed control (Paarlberg and Paarlberg 2000, XV-XVI). This industrial agricultural landscape has led to problems such as over extraction of soil nutrients, stresses on the water supply, a loss of biodiversity, and monoculture crops that are more susceptible to disease and pests (Fox 2011, 27-29).

Additionally, the U.S. food system follows a centralized pattern; with food processing, packaging, and distribution sited in centralized locations rather than at smaller, dispersed hubs. A centralized system can create vulnerability, where interferences such as changing climate patterns, shifting development, urbanization, pests, and pathogens can disrupt or impair the food system. These disruptions are more easily absorbed in a decentralized system (Brown et. al 2015). Therefore, the emergence of the modern industrialized food system, while responding to challenges in food

production, has perhaps unintentionally threatened the food security of people across the country and the world.

To feed a growing world population, corporations and nations have attempted to maximize food production as inexpensively as possible and, while successful, these efforts have created unintended problems of access to quality food (Timmer et al. 1983, 2). The obstacles to accessing quality foods have increased the gap between food and people, both spatially and nutritionally, and caused communities across the nation to suffer from food insecurity. A lack of access to nutritional food has led to poor diets that involve high caloric consumption, but inadequate nutrient intake (Lawson and Knox 2002). Moreover, the same people that suffer from food insecurity are often the same who are prone to higher rates of health issues such as diabetes, stroke, asthma, obesity, heart disease, and cancer (Cohen et al. 2004). In sum, as an unexpected consequence of large-scale food production and centralization, the modern food system has put a strain on community health, especially regarding people's ability to access food and obtain quality, nutritious food.

South Dakota is not immune from these health concerns and nutrient deficiencies. According to data from the Centers for Disease Control and Prevention (CDC), as of 2015, the state has the 20th highest obesity rate in the U.S. at 30.4%, and the state's largest city, Sioux Falls, has an obesity rate of 27.4%. These rates coincide with the national average of 29.8%. South Dakota has been experiencing an increase in obesity since the mid-1990s (South Dakota Dashboard 2018) (Figure 1). Even though the obesity rate in Sioux Falls is slightly below the national average, an acknowledgement of the

threat remains. For example, the City is working toward improving nutrition in schools, and developing community health programs (Community Health Status Report 2012).

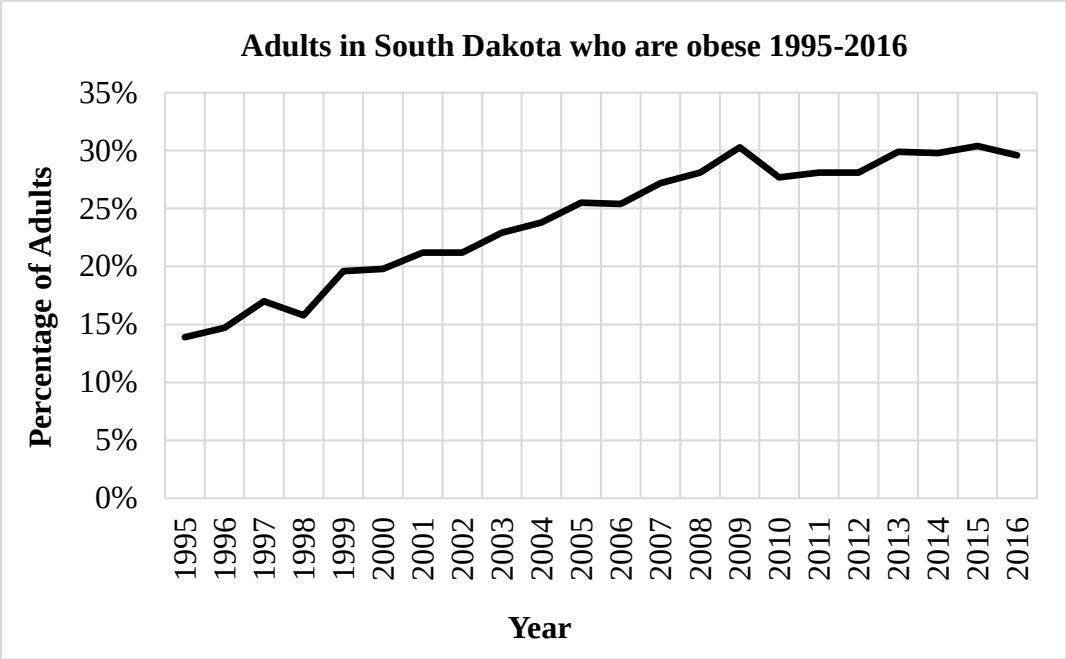

Figure 1: Percentage of adults who were obese between the years of 1995 and 2016. Data source: South Dakota Dashboard 2018.

A range of options exists within urban areas to enhance opportunities for achieving food security. This research explores the role of urban gardens as a tool to help address food insecurity in Sioux Falls, SD. The project examines experiences of gardeners and how urban gardens have affected perceived food security in gardeners' lives. Additionally, this research looks at the nutritional quality of urban garden produce as it compares to store-bought equivalents. More specifically, this research investigates how the presence of urban gardens in Sioux Falls, SD affects food security regarding access and consumption of nutritional food for the surrounding community. The objective is to increase our understanding of how urban gardeners use their food and the impact that garden produce has on nutrition in their lives. The results of this research

will illustrate the role community gardens play in providing nutrition to local people, and how this practice promotes one aspect of food security.

CHAPTER 2: LITERATURE REVIEW

2.1 Food Insecurity and Nutrition

Food security is described by the Food and Agriculture Organization (FAO) of the United Nations as the "physical and economic access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle" (FAO 1996, 1). Essentially, being food insecure means a condition of insufficient access to adequate food (United States Department of Agriculture (USDA) 2017). Households considered food insecure do not necessarily need to be in a constant state of insecurity. Insecurity in many cases may involve a household being required to choose between basic needs, such as housing, utilities, or medical bills, and buying adequate and nutritious foods (Feeding America 2015). Generally, insecurity is generated by structures of government subsidies, globalized trade, a narrowing food base, wealth inequality, increased poverty, and lack of food sovereignty (Chappell and LaValle 2011, 3). The FAO describes four dimensions of food security. The first is the availability and supply of food. The second examines access to food from the perspectives of income, expenditure, and buying capacity of individuals. The third focuses on utilization, or how much, what, and how people eat. The fourth involves the stability of all dimensions over time. These aspects of food security are identified by the FAO because "for food security objectives to be realized, all four dimensions must be fulfilled simultaneously" (FAO 2008, 1).

The USDA has reported a general downwards trend in the share of U.S. households that are food insecure at some point through the year (Figure 2). In 2011, 14.9% of households were food insecure and by 2016, this number had decreased to

12.3%, which equates to roughly 15.6 million households. The USDA also lists data, based on individuals, that indicate 12.9% of all individuals in the U.S. were food insecure as of 2016, equating to roughly 41.2 million people (see Figure 3) (Coleman-Jensen et al. 2017). Additionally, Feeding America (2015) reports food insecurity rates at both the state and county levels for the year 2015. At the state level, South Dakota reports 12.1% of individuals as food insecure. At the county level, Sioux Falls is located in Minnehaha and Lincoln Counties, Minnehaha County reports 11.6% of its population as food insecure (i.e., 20,830 individuals), and Lincoln County with 7.9% as food insecure (i.e., 3,950 individuals) (Feeding America 2015).

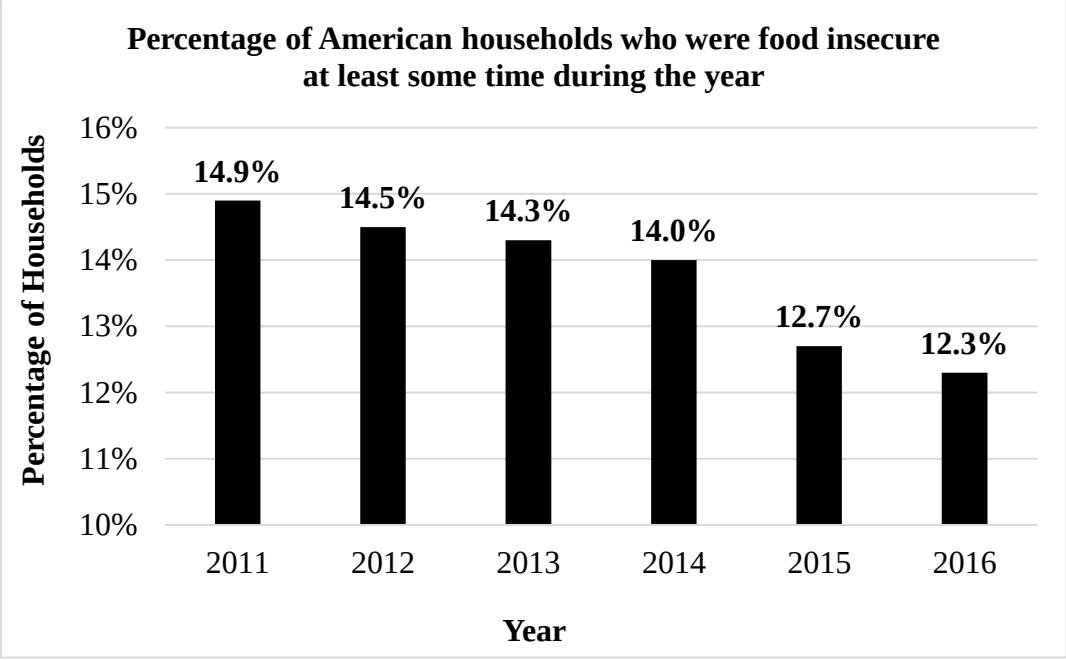

Figure 2: Percentage of American households who were food insecure at least some time during the year. Data source: Coleman-Jensen et al. 2017.

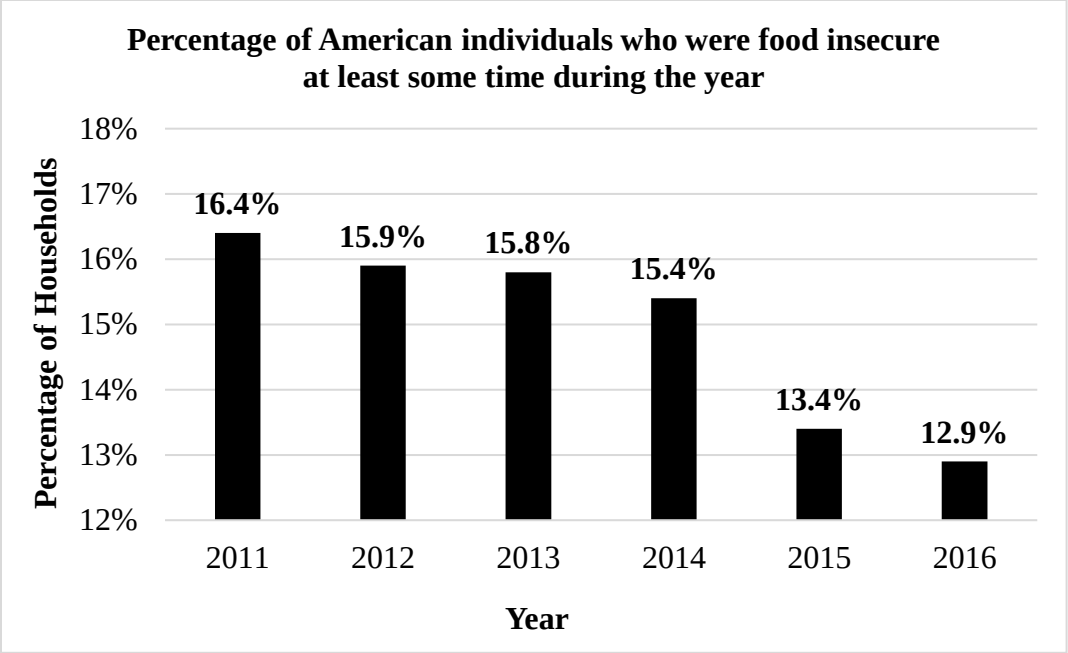

Figure 3: Percentage of American individuals who were food insecure at least some time during the year. Data source: Coleman-Jensen et al. 2017.

Despite declining rates of food insecurity in the U.S., millions of people still go hungry. Rates of food insecurity tend to be highest for single-family minority households with incomes below the poverty line. According to some experts, higher rates of food insecurity are the result of low-income consumers having fewer food shopping choices than middle-income consumers, including fewer retail options and limited transportation options (Brown and Carter 2003). Additional hurdles arise for consumers who shop at supermarkets and convenience stores where, when available, fresh produce often costs more than products that are lower in quality and nutritional value (Lawson and Knox 2002).

Lack of convenient access to nutritional foods coupled with limited economic resources results in food security barriers for many urban area residents. These barriers then diminish the likelihood that citizens will make healthy eating choices (Treuhaft and Karpyn 2010, 21). Consequently, to reduce grocery bills and food costs, many people

select nutrient-poor foods that may often lead to health problems. Additionally, this lack of access, or even burdensome access to quality food creates obstacles for people to achieve potential improvements in their diet (Morland and Evenson 2009, 495).

Easy and low-cost access to unhealthy foods has led to a linkage between food insecurity and inadequate nutrition. Inadequate nutrition has been associated with school and work absences, fatigue, and difficulties with concentration, an increase in occurrence of infectious diseases, and several chronic diseases such as diabetes, hypertension, and heart failure (Brown and Carter 2003). Furthermore, because higher food costs represent an obstacle to dietary improvement, the ability to adopt healthier diets often has less to do with self-motivation, or readiness to change, and more to do with a person's economic resources and the food environment they are exposed to (Drewnowski 2004, 161). All over the country, obesity and health issues impact a higher proportion of low-income communities (McClintock 2011, 90). Studies across the country, however, have investigated the connection between improved diets and improving the food environment for these communities. Such examples include: a study in North Carolina that involved community gardens used in an obesity prevention program and showed gardens to have a positive impact on increasing fruit and vegetable consumption and preventing childhood obesity (Castro et al. 2013, 193); a study in Minnesota that demonstrated how youth garden-based nutrition education helped increase fruit and vegetable consumption in participants (Lautenschlager & Smith 2007, 129); and, a study in Flint, MI that found, "adults with a household member who participated in a community garden consumed fruits and vegetables 1.4 more times per day than those who did not participate" (Alaimo

et al. 2008, 94). The findings of these studies suggest that urban agriculture often aides and improves the food environment.

2.2 Nutrient Density

The current western diet focuses on the intake of foods with high caloric density, but low nutritional content, consisting of more processed foods and fewer fresh fruits and vegetables (Martin et al. 2013, 26). However, awareness on the nutrient content of foods is becoming a matter of global and national importance, especially "given the prevalence of malnutrition, including obesity (due to over-consumption of foods high in energy yet low in nutritional density), and the negative health impacts they produce" (Kingwell et al. 2015, 73). Consumption of fruits and vegetables adds more nutrients to diets and has been proven to help reduce risk of heart disease, stroke, and helps manage body weight (United States Department of Health and Human Services (HHS) 2010, 35). Consequently, HHS (2005, 24) has recommended, in the *Dietary Guidelines for Americans,* that people eat a variety of nutrient dense foods, and consume five or more servings of fruits and vegetables per day.

While there is some debate on what signifies a nutrient dense food (Drewnowski 2005, 721), foods that supply generous amounts of one or more nutrients relative to the number of calories they supply are generally considered nutrient dense (University of Clemson Cooperative Extension 2006). Examples of "nutrient dense" foods include vegetables, fruits, whole grains, fat-free or low-fat milk and milk products, seafood, lean meats and poultry, eggs, beans and peas, and nuts and seeds (HHS 2010, 94). These nutrient dense foods such as fruits and vegetables are the same foods generally associated

with urban agriculture, ranging from farmer's markets to rooftop gardens, and community gardening.

2.3 Nutrition, Food Security and Sioux Falls

In addition to food insecurity, many Sioux Falls residents also experience poor nutrition. In 2016, the most recent Community Health Needs Assessment (CHNA) was conducted across the Sioux Falls Metropolitan Statistical Area (MSA) by the Sioux Falls health department and the two major health systems in the city (i.e., Avera McKennan and Sanford Health). Previously, these three entities created separate assessments. The Sioux Falls MSA includes Minnehaha and Lincoln Counties, the two counties in which Sioux Falls resides, as well as nearby McCook and Turner Counties (Figure 4).

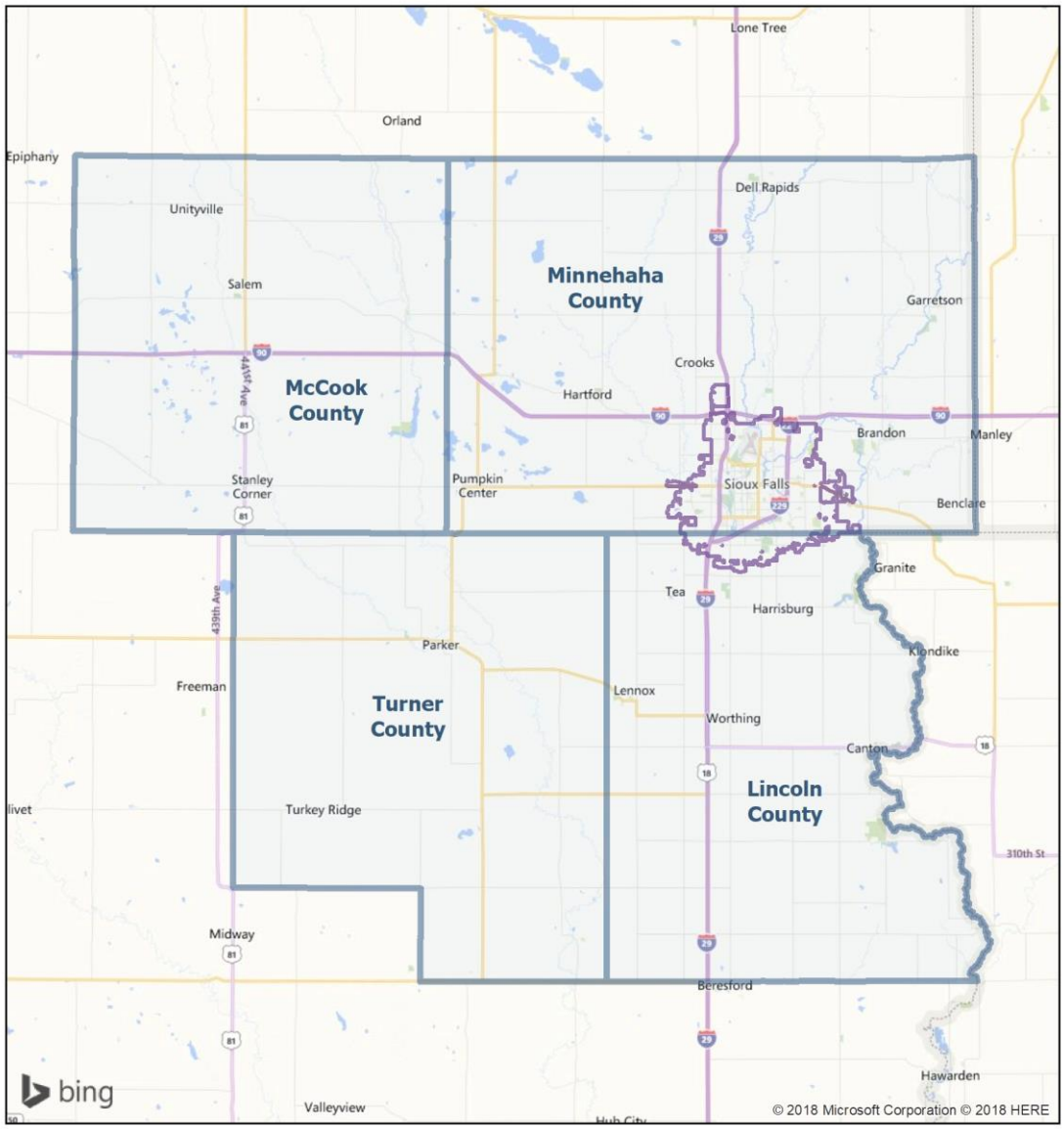

Figure 4: Counties that comprise the Sioux Falls MSA. Data source: United States Census Bureau 2016. Map created by author using ArcMap with Bing basemap.

In order to help develop a better understanding of the health status of residents within an MSA, communities complete CHNAs. While the assessment measured several survey items such as behavioral health, access to healthcare, and physical activity, the results raised some concerns regarding nutrition across the area (Community Health Status Report 2016). Additionally, the previous CHNA, completed in 2012 by the Sioux Falls Health Department, mentioned that, as of 2009, only 12.6% of adults consumed the

recommended amount of fruits and vegetables per day, compared with 15.7% in South Dakota, and 23.5% nationwide (Community Health Status Report 2012, 3-4). These results were derived from a 2009 Behavioral Risk Factor Surveillance System (BFRSS) report, and additional trends can be seen from BFRSS reports for various years between 2002 and 2009, in Figure 5 (CDC 2002, 2003, 2005, 2007, 2009).

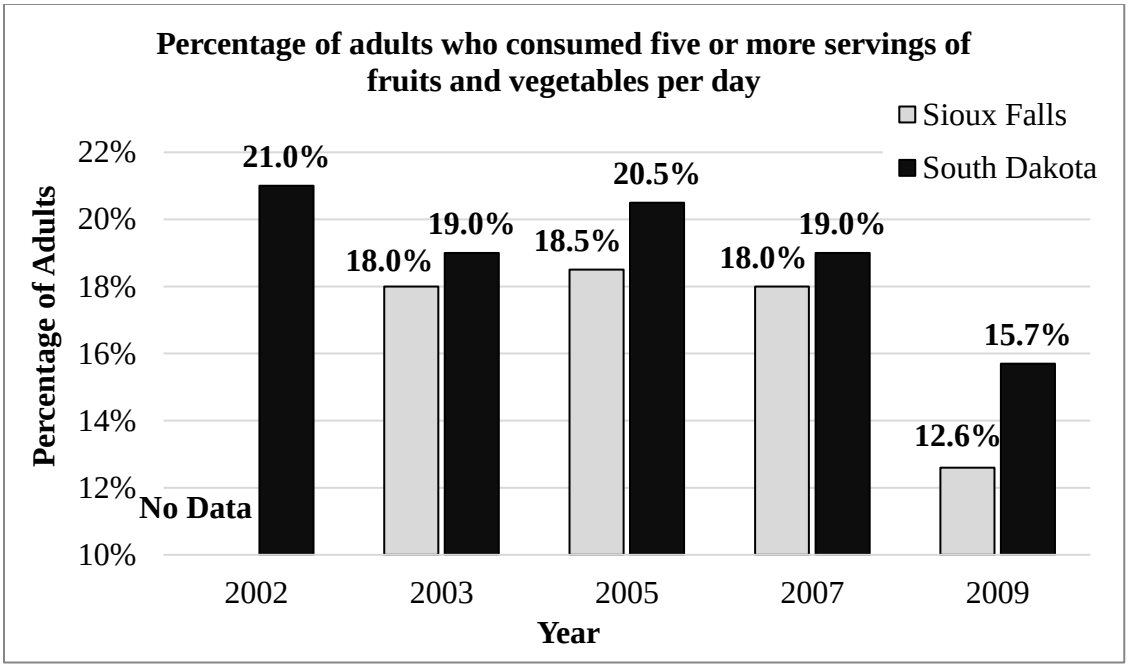

Figure 5: Percentage of adults who consumed five or more servings of fruits and vegetables per day. Data source: CDC 2002, 2003, 2005, 2007, 2009.

The 2016 CHNA also mentions that the sampling method changed for the BRFSS data in 2011, and thus new measurements cannot be appropriately compared to past numbers. For the residents surveyed in the CHNA, fruit and vegetable consumption were measured separately, with the assessment reporting only 6.1% of residents who ate 4 or 5 servings of fruits a day, and only 8.1% who ate 4 or 5 servings of vegetables a day (Community Health Status Report 2016, 69). While the BRFSS advises against

comparing the new data to past years, the numbers show a considerably low percentage of the population consumes an adequate amount of fruits and vegetables.

Additionally, the CHNA, through resident surveys, identified other health issues regarding nutrition, including obesity and diabetes. The assessment identified obesity as the primary health concern for the residents, with over two-thirds of adults being overweight (36%) or obese (31%) in a 2015 resident survey (Community Health Status Report 2016, 60). The results of this survey show a slightly higher percentage than data presented previously in the literature by the CDC, which indicated that 27.6% of Sioux Falls' population were categorized as obese in 2015. These numbers show a slight upward trend for obesity, when looking back on BRFSS data from 2007 to 2010 that are illustrated in Figure 6 (CDC 2007-2010).

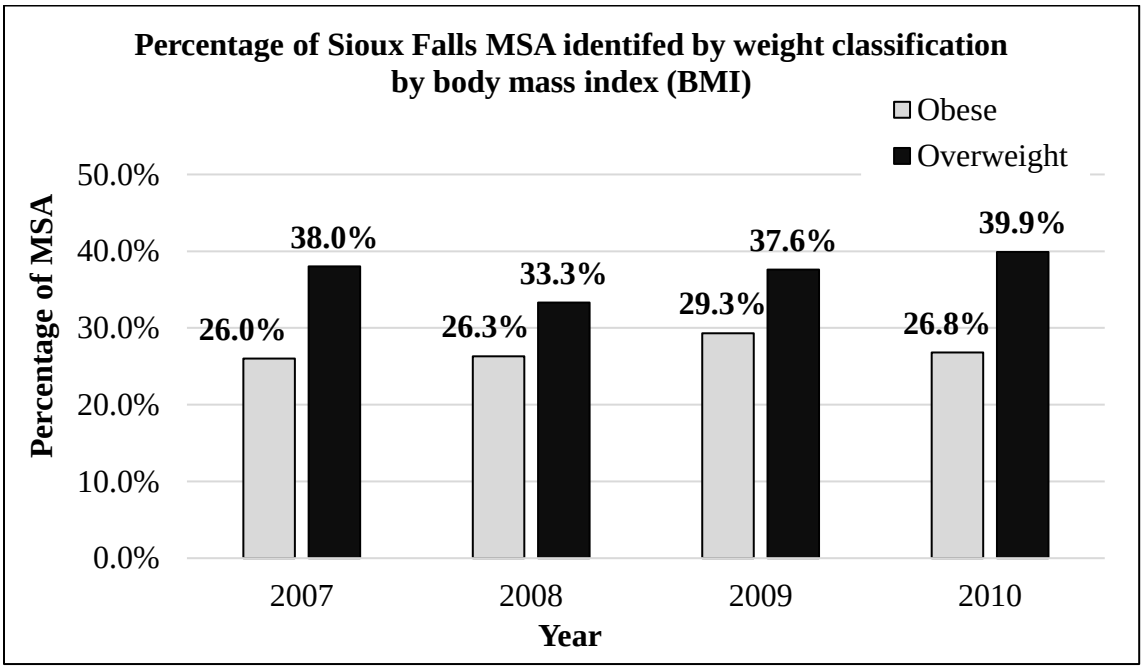

Figure 6: Percentage of the Sioux Falls MSA identified by weight classification by body mass index (BMI). Data source: CDC 2007-2010.

While obesity is a primary concern in the Sioux Falls MSA, a 2012 BRFSS report indicated that 8.3% of adults in the Sioux Falls MSA have diabetes compared to 9.2% in

South Dakota and 9.8% in the U.S. (CDC 2012). In this case, the Sioux Falls MSA fared better than South Dakota and the U.S. However, Type 2 diabetes is an obesity-related health condition that is typically preventable, and primarily affects adults, but is increasingly affecting children as well. For these reasons, the CHNA identifies diabetes as a key health concern.

The groups conducting the assessment indicated numerous strategies to address these issues, including increasing healthy food options. For example, one strategy includes providing more appealing and accessible health food options in schools. Another strategy calls for improved accessibility, placement, and promotion of fruits and vegetables in stores, restaurants and in the community. Lastly, the report called for better policies for worksites to ensure that ample fruits and vegetables are provided (Community Health Status Report 2016, 70). The CHNA shows both the acknowledgment that obesity and other health problems exist in the City and recognizes the measures and strategies to address these health problems.

2.4 Trend toward Local Food Production

In response to problems related to food insecurity, a changing climate, and a growing population, alternative food systems have emerged, thus shifting the focus of agricultural production toward increased local production (Frison et al. 2006, 167). Alternative food systems are generally seen as a range of management and technological opportunities used to reduce costs, protect human health and the environment, promote biodiversity and dietary diversity, and enhance biological interactions and natural processes (National Research Council 1989, 27). In general, differences in operations between alternative and conventional industrial agriculture stem from alternative methods

that aim to lower or eliminate use of pesticides and inorganic fertilizers, and eliminate mechanization where practical, all of which attempt to decrease consumption and overall reliance on fossil fuels.

Fossil fuel consumption is limited by reducing use of industrial farm equipment and decreasing food miles, or the distance food travels (in miles) from producer to consumer. The food mile gap between producer and consumer becomes alarmingly apparent when, in the current food system, "food can travel an average of 1,300 to 1,600 miles, changing hands five or six times before it reaches the consumer's table" (Goreham and Stofferhahn 2001, 24). Goals aimed at decreasing food miles have helped sprout popular farm-to-table movements globally, encouraging consumers to know where their food comes from and to support local farmers. Movements, such as "Know Your Farmer Know Your Food" have been promoted by the USDA as a country-wide effort to support local and regional food systems through cultivating healthy eating habits and expanding access to healthy foods (USDA 2015).

Local food production has also increased as clear links have been identified between food deserts, poor diets and nutrition, and obesity (USDA 2009, 1). Food deserts have been defined by the USDA as "[l]ow-income census tracts with a substantial number or share of residents with low levels of access to retail outlets selling healthy and affordable foods…" (Ver Ploeg et al. 2011, 46). Low-income census tracts are defined as those with a poverty rate greater than 20% and a median family income below 80% of the median family income of the state. Additionally, census tracts identified as low access by the USDA are those where 500 people or more and/or 33% or more of the census tract's population reside farther than one mile from a grocery store (Rhone et al. 2017, 3-4).

Thus, fast food restaurants and convenience stores may only serve people in food deserts, which are less expensive and filled with processed and empty calorie foods that contribute to obesity and poor nutrition. Locations of census tracts flagged as being food deserts, varying by definition, can be seen in Figures 7, 8, 9, and 10. Whether food deserts form due to income inequality or lack of transportation infrastructure, local food sources such as farmers markets and urban gardening have been identified as ways to fill in these "food voids" (USDA 2009).

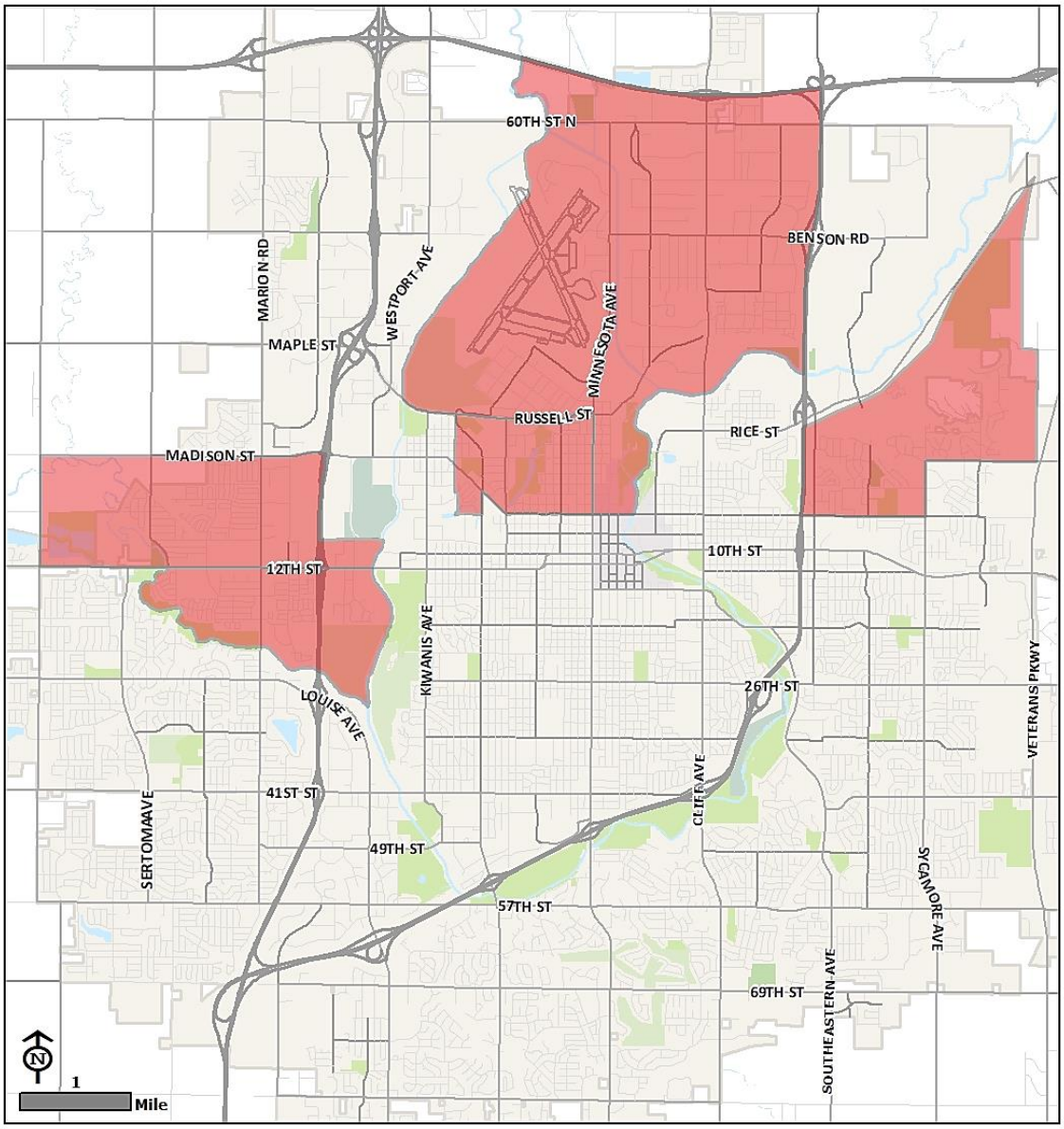

Figure 7: Sioux Falls MSA food deserts based on one-mile definition. Shaded areas indicate census tracts flagged as food deserts or low-income census tracts with at least 33% of the population residing more than one mile from a grocery store. Data source: ERS 2017 and City of Sioux Falls 2017. Map created by author using ArcMap.

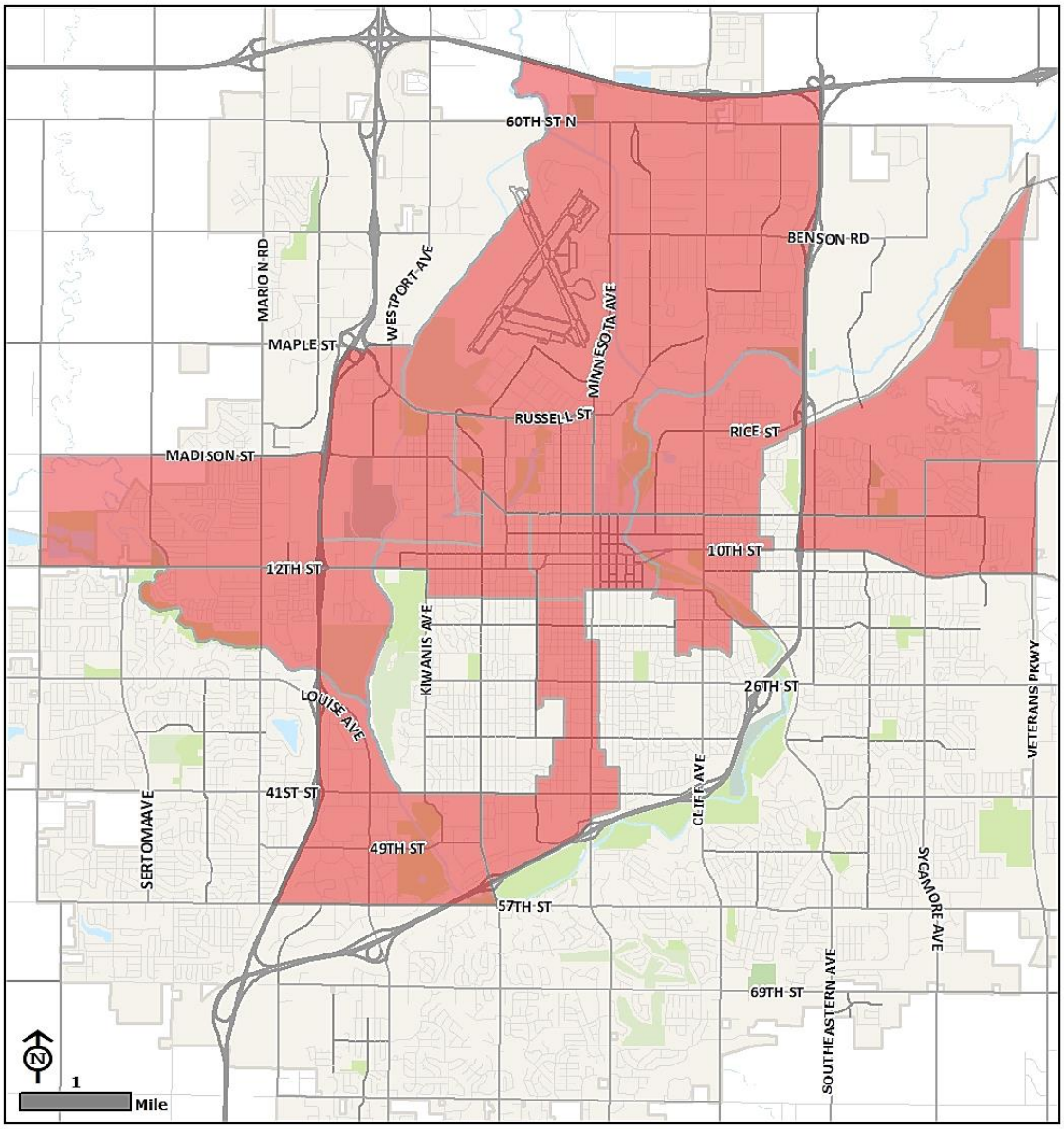

Figure 8: Sioux Falls MSA food deserts based on one half-mile definition. Shaded areas indicate census tracts flagged as food deserts or low-income census tracts with at least 33% of the population residing more than one half-mile from a grocery store. Data Source: ERS 2017 and City of Sioux Falls 2017. Map created by author using ArcMap.

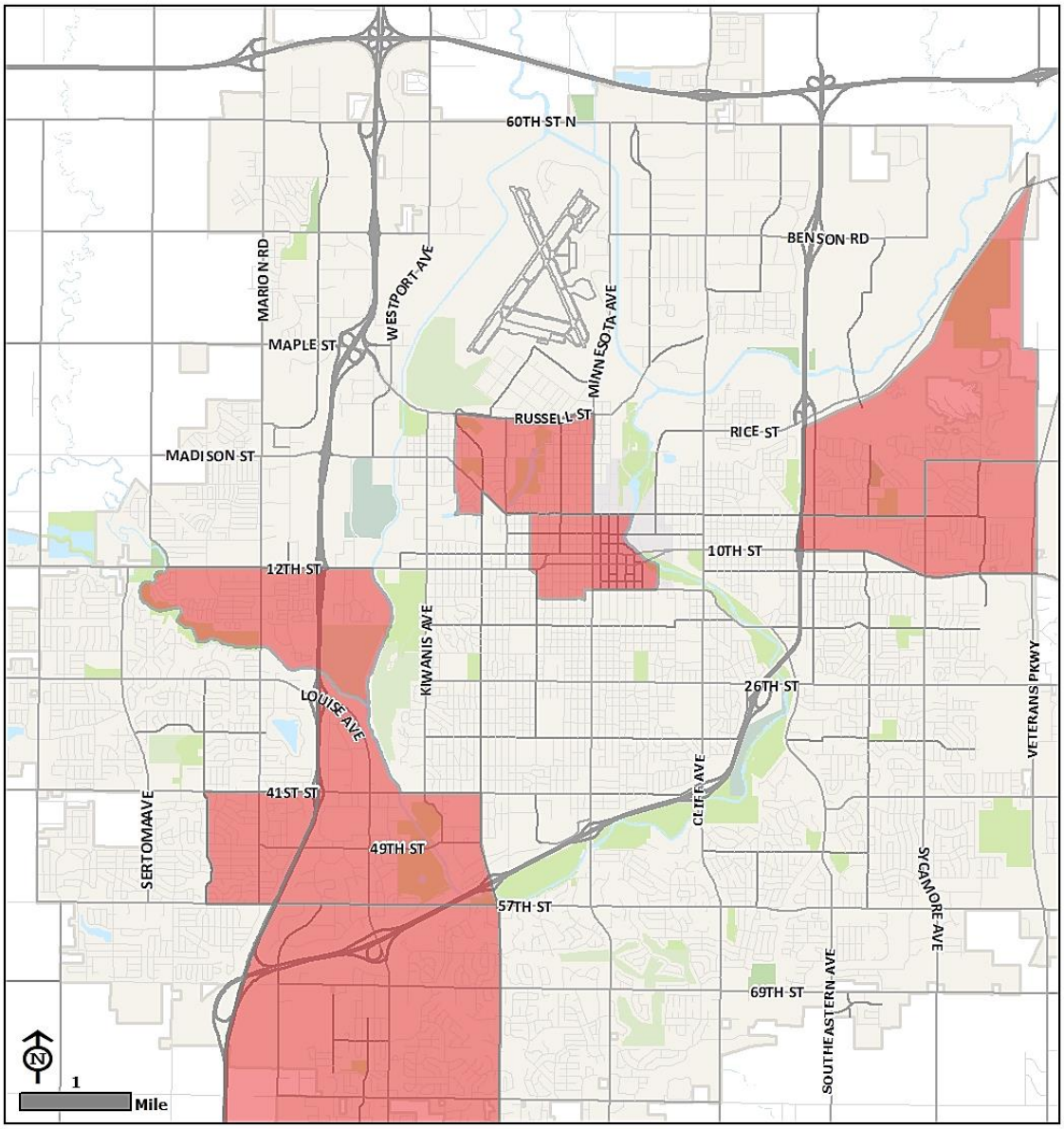

Figure 9: Sioux Falls MSA food deserts based on vehicle access and one half-mile definition. Shaded areas indicate census tracts where at least 100 housing units do not have a vehicle, and are more than a half mile from the nearest grocery store. Data source: ERS 2017 and City of Sioux Falls 2017. Map created by author using ArcMap.

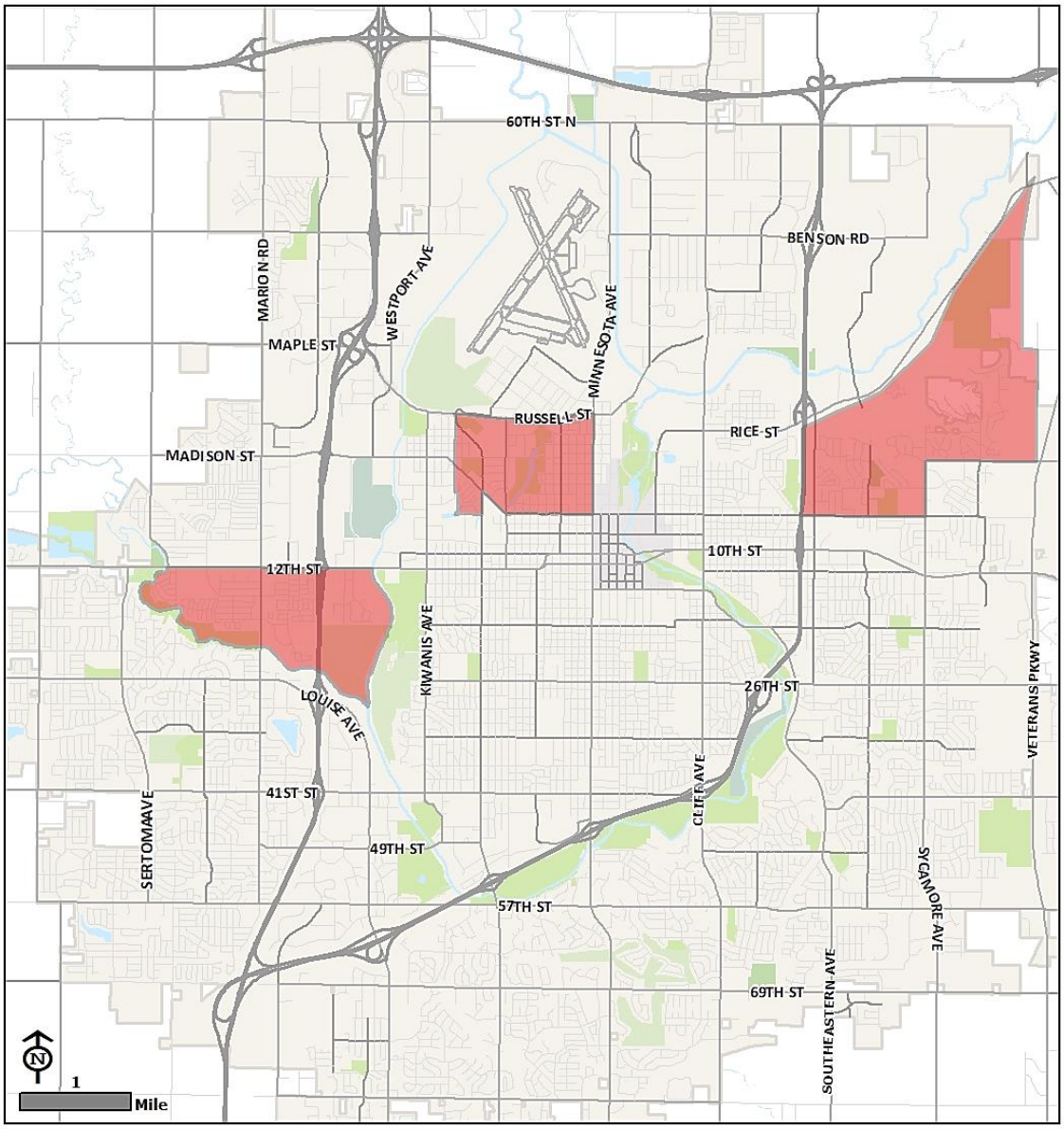

Figure 10: Sioux Falls MSA food deserts based on vehicle access, one half-mile, and one-mile definitions. Shaded areas indicate census tracts where Figures 7, 8, and 9 overlap. Data source: ERS 2017 and City of Sioux Falls 2017. Map created by author using ArcMap.

2.5 Urban Gardening and Community Gardens

Recognition of urban gardens as a means for sustainable urbanization (Colasanti 2013, 350) along with growing concerns about the quality, cost, and insecurity of food have increased interest in growing food locally in cities through urban gardening

(Corrigan 2011, 1232). While private backyard gardens involve the growing of produce on private individual lots for homeowners, community gardens appear in parks, urban open spaces, and even informal spaces like vacant lots (Pudup 2008, 1233). Community gardens can be loosely defined as, "an alternative park system" consisting of growing produce in "any green place designed, developed or managed by local residents for their use and enjoyment of those in the community" (Francis 1994, 1).

Backyard gardens and private gardens have been prevalent in the U.S. for centuries. However, urban gardening specifically through community gardens has existed in the U.S. only since the 1890's. In cities such as Detroit and Philadelphia, gardens sprouted on vacant lots in response to the economic recession and, thus, eased some of the resulting poverty and hunger (Smithsonian Institution 2017). Through World Wars I, and II, community gardens were started as "Victory Gardens" and encouraged by the U.S. government as an act of patriotism. "Keeping it local helped to feed communities and families as well as provide for the soldiers" (Andreatta 2015, 39). Within the past few decades, community gardens have emerged through trends in attention to social, health, and economic problems faced by cities as well as a nationwide increase in environmental consciousness (University of Missouri Extension 2009). From 2008 to 2013, the number of gardens in the U.S. grew from 36 million households to 42 million, a growth of 17%, according to a report issued by the National Gardening Association (National Gardening Association 2014).

Community and private backyard gardens can aim for many of the same goals that sustainable development hopes to address. These goals point to elements of environmental protection, holistic management, and cultivation methods such as

permaculture. Additionally, gardens, especially community gardens, create a setting of social inclusion that embraces educational programs and community development activities to increase understanding and participation in food production and supply amongst citizens. These factors are important for developing the concept of sustainability in places; "…community gardens can provide a model of sustainability in action" (Holland 2004, 304). Furthermore, decreasing the subjective and objective distance between people and healthy food have substantial potential for far-reaching positive impacts on community and personal well-being.

The role of urban gardens in cities varies with scale and place. At the community level, this role ranges from filling market gaps and establishing alternative food systems to integrating with current food systems and socioeconomic dimensions of urban areas (Colasanti 2013, 349). On an individual level, urban gardens make fresh food available for consumption, enable gardeners to enjoy nature, improve the health of gardeners, and help gardeners save or make money (Guitart et al. 2012, 367). Gardens serve as a way to reconnect people with food sources and those who do not always have access to nutritious food outlets (Twiss et al. 2003, 1435). Additionally, communities create gardens with the purpose of building and improving the welfare of groups and communities (Holland 2004, 303).

2.6 Urban Gardening Benefits

Gardening can provide a range of mental, spiritual, and physical health benefits. Urban gardening benefits include increased social interaction (Guitart et al. 2012, 367), improved health through exercise and an active lifestyle (Van den Berg, Marijke, and de Vries 2010, 83), and improved diets through quality and variety of produce consumed

(Blair, Giesecke, and Sherman 1991, 166). Other studies have demonstrated the psychological benefits provided by reconnecting with nature (Milligan et al. 2004, 1790) and educational benefits in schools where students gain knowledge related to nutrition and natural sciences through applied learning (Graham et al. 2005, 149).

Gardens provide economic and environmental benefits as well. Economic benefits include improved values in properties near gardens (Broadway 2009, 24), money saved by growing one's own produce (Schmelzkopf 1996, 380), and poverty relief (Hanna and Oh 2000, 215). Additionally, since the 1970s, community gardens have been organized to enhance conditions in urban areas associated with urban renewal and gentrification (Pudup 2008, 1232). Environmentally, gardens emerge as a response to climate change, to promote local foods, and to help decrease distribution costs of food transportation by limiting fossil fuel consumption (Dixon et al. 2009, 17). Improved biodiversity related to pollinating insects (Matteson et al. 2008, 149) and increased crop diversity (Mundel and Chapman 2010, 172) have been noted benefits as well. Lastly, food production on underutilized space, such as vacant or empty lots, has been promoted as a model of environmental sustainability (Holland 2004, 303). The social, economic, health, and environmental benefits collectively illustrate how urban gardens can help mitigate food insecurity issues faced by individuals, households, and communities.

CHAPTER 3: METHODS

3.1 Framing the Problem and Study Area

The problem of global food insecurity faced by individuals, households, and communities throughout the world is often associated with low-income circumstances. On broader scales, food insecurity results from flaws in the global food system. Food system issues at local and regional scales can be partly attributed to a lack of political will in providing support at the state and national level, support that could strengthen local food systems. Additional issues include lack of knowledge about food and nutrition among people at the local and community level. While global food systems are difficult to change, the lack of knowledge and the vast array of potential solutions among local communities and households for increasing nutrition and improving the food system bring opportunity for improvement in food security. Urban gardens offer a potential local and community-wide solution.

Food insecurity occurs at global through local scales. This research focuses on how community gardens impact the utilization dimension of food insecurity at the local scale, using a case study of urban gardens in Sioux Falls, SD (Figure 11). As mentioned previously, utilization, one of the four dimensions of food security laid out by the FAO, is the aspect of food insecurity that addresses how much, what, and how people eat, and thus is closely related to nutrition.

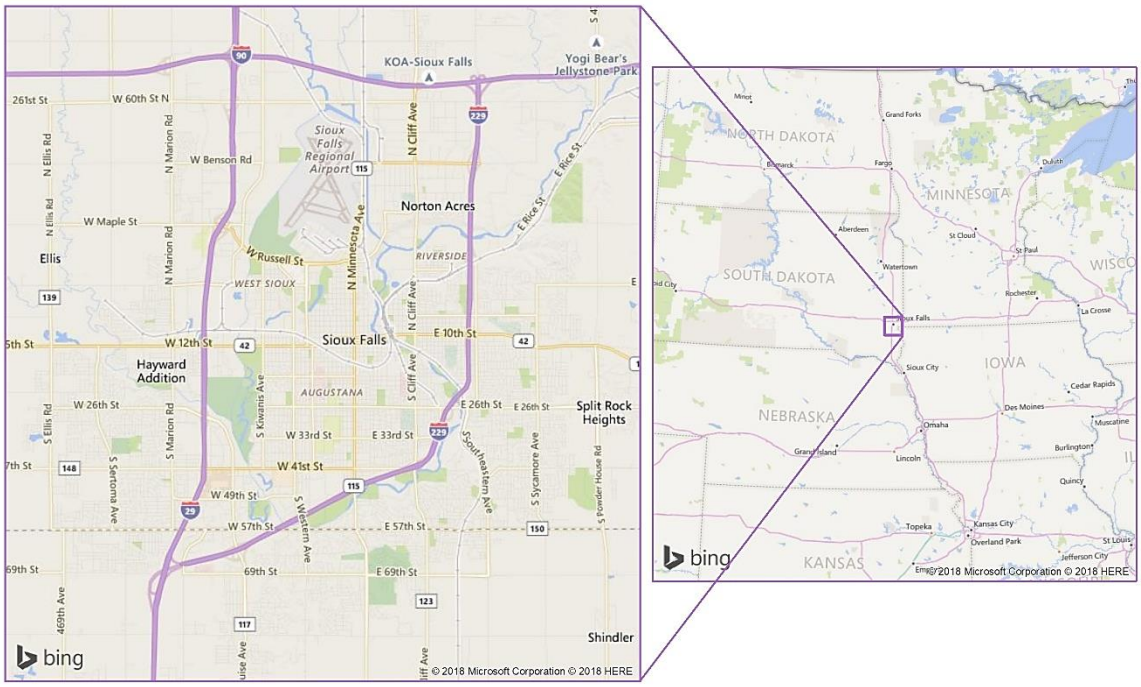

Figure 11: Map showing the location of the study area, Sioux Falls, SD. Map created by author using ArcMap with Bing basemap.

The South Dakota Department of Health identifies poor nutrition as one of the leading causes of obesity in the state and primarily focuses on preventative measures associated with childhood obesity. These measures aim to increase training, technical assistance and resources for schools and other organizations, to develop healthier food environments and empower children to make healthy eating habits (South Dakota Department of Health 2015). Obesity rates in South Dakota have risen steadily since the 1990s from 10.7% to the recent rates of 29.8% in 2014, and 30.4% in 2015, giving South Dakota the 20th highest obesity rate across the country as of 2015 (Levi et al. 2015; South Dakota Dashboard 2018). This research seeks to improve our understanding of the relationship between negative health trends in a major population center of South Dakota and the positive impacts of community gardens on food security, especially relating to nutrition.

Sioux Falls has numerous community gardens spread across the city. Ten of these gardens were used in this study, as can be seen in Figure 12 (City of Sioux Falls 2015). These gardens comprise a case study, aiming to help further understand the relationship between urban gardens and local food security. The Sioux Falls MSA encompasses McCook, Turner, Lincoln, and Minnehaha Counties; however, the city limits of Sioux Falls cover just Minnehaha and Lincoln Counties, and as there does not appear to be any community gardens outside of the Sioux Falls urban area. Consequently, the boundaries of the study area were selected to coincide with the city limits of Sioux Falls.

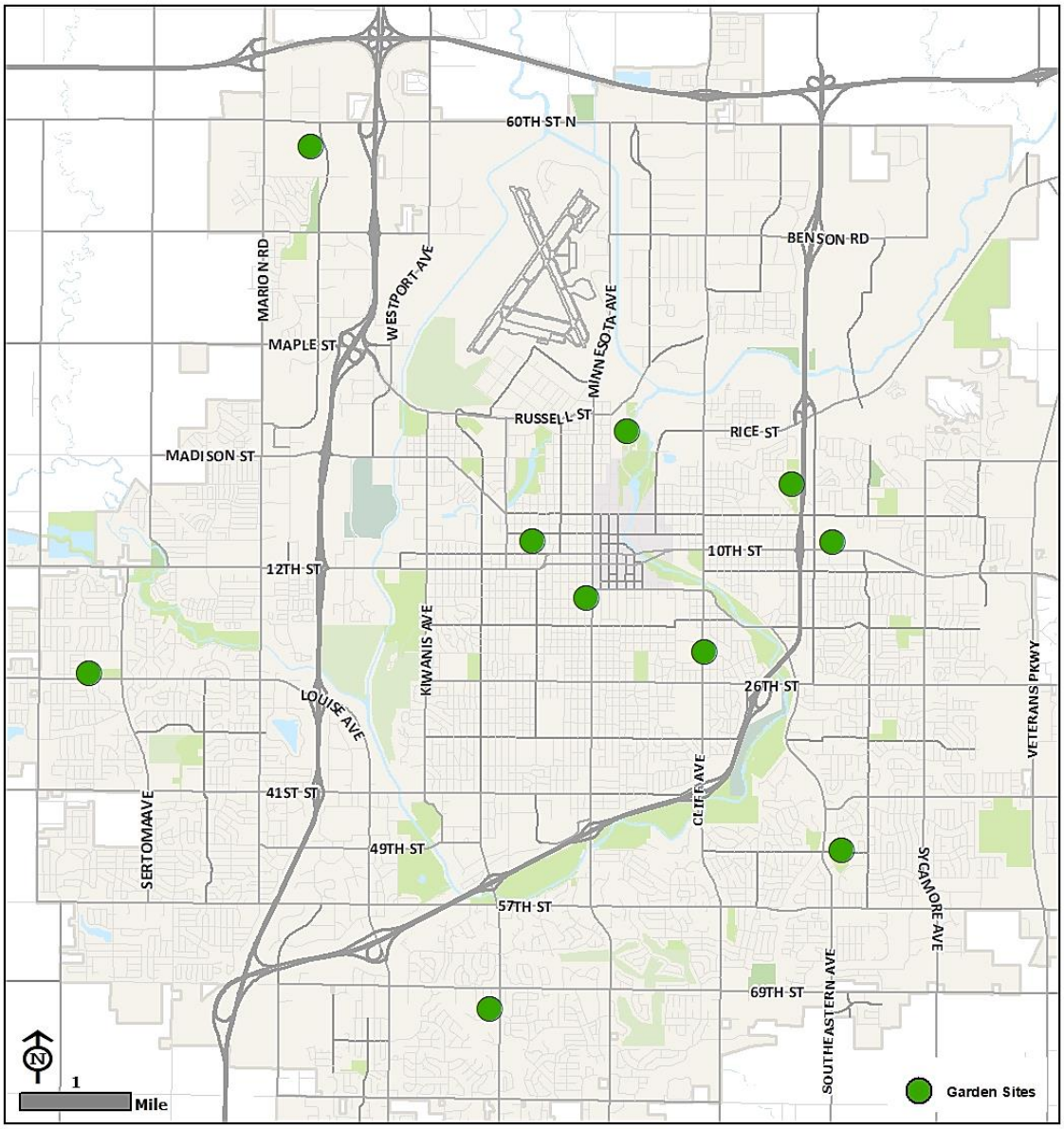

Figure 12: Location of community gardens in Sioux Falls, SD. Additional community and private gardens are not shown. Data source: City of Sioux Falls 2015 and City of Sioux Falls 2017. Map created by author using ArcMap.

The study seeks to build an understanding of local food production and its connections to nutrition of individuals, families, and the surrounding community. This research employed both qualitative and quantitative methods. A survey was used to collect information about gardeners' subjective experiences and perceptions of the utilization dimension of food insecurity, in order to better understand linkages between

urban gardens and perceived access to nutritious food. Through laboratory analyses, the nutritional differences between produce purchased at the nearest grocery stores to that grown in community gardens were quantitatively compared.

3.2 Research Questions and Objectives

This research investigates whether urban gardens in Sioux Falls, SD affect the FAO defined utilization dimension of food security for the community. The objective is to increase our understanding of how urban gardeners utilize the food they grow, and the impact of garden produce on nutrition in their lives. The results provide insights into the role community gardens play in enhancing nutrition of local people, and, ultimately, in addressing food insecurity.

The first set of research questions pertain to the motivations for gardening and eating behaviors. The specific research questions that were addressed include:

1.1 What motivations led community members to begin gardening?

1.2 How have urban gardens impacted access to nutritional food?

1.3 How have food purchasing patterns changed?

1.4 How have diets changed since beginning to garden? Is this only a seasonal shift or does the change last year-round?

1.5 How many servings of fruits and vegetables do gardeners, their family members, and community members eat daily?

1.6 If gardeners eat more vegetables that they grow in their gardens versus produce bought from the store, what are the deciding factors: availability, convenience, cost, flavor, or something else?

The second set of research questions pertain to the quality of produce, namely nutrient density and taste, from grocery stores and community gardens in Sioux Falls. The produce compared was tomatoes, since most gardeners include this item in their gardens. The specific research questions addressed include:

2.1 Where would urban gardeners buy or acquire produce other than gardens?

2.2 What is the nutritional quality of this produce compared to their home garden?

2.3 Does fresh garden produce have higher Brix (i.e., does it taste better) and higher nutrient levels than the store-bought equivalent?

3.3 Data Collection and Analysis

The objectives for this research required collection of two separate, yet related, datasets. The data were used to help make connections between urban gardening and food security in the case of Sioux Falls, SD.

3.3.1 Data Collection: Eating Behaviors

The first objective of this project aimed to determine motivations for gardening and how community gardens affect eating behaviors for individuals in the area. Thus, regarding this research objective, it was important to collect qualitative data from urban gardeners describing their motivations, perceived benefits, produce consumption patterns, and experiences associated with gardening activities. A questionnaire was developed and deployed to capture these motivations, perceived benefits, and eating patterns of Sioux Falls urban gardeners. Questions solicited primarily yes/no responses, along with multiple choice and short-answer formats, in order to simplify the analysis of responses. While the complete survey is illustrated in Appendix A, some representative questions

included in the survey are as follows. Do you eat more produce since you began gardening, and why? What is the primary reason you began gardening? How many servings of fruits and vegetables do you eat per day? Other than your garden, where do you obtain your fresh fruits and vegetables?

Surveys were conducted online, using Survey Monkey, and distributed to potential respondents via web URL. Some questions and the format of the survey are illustrated in Figure 13. With the aid of Karin Woltjer, Minnehaha County Master Gardener and Garden Coordinator, the surveys were distributed to the population of urban gardeners through email, for them to complete at their convenience.

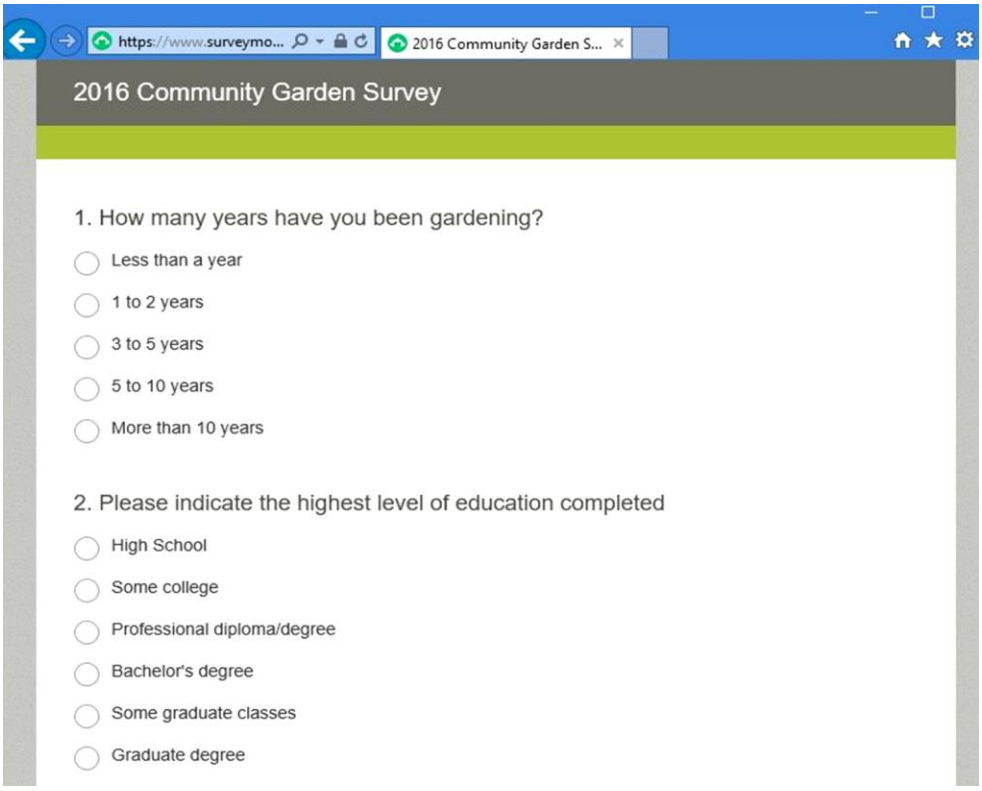

Figure 13: Illustration of the online survey distributed via Survey Monkey.

3.3.2 Data Collection: Produce Quality

The second objective focused on comparing measurable produce quality (i.e., taste and nutrient density) between urban gardens and the store-bought analogue. In this study, high produce quality refers to produce that has high taste quality, while also being nutrient dense. The quality of taste for produce is measured here, because it is assumed that an increase in taste quality parallels an increase in produce consumed. Additionally, those foods higher in nutrients compared to the number of calories they supply are considered nutrient dense, and their consumption leads to increased nutrition.

Data collection included obtaining samples of produce from community gardens and from grocery stores on the same day. Since gardeners had to be willing to provide freshly harvested tomato samples, collecting tomatoes was done through opportunistic sampling. The sampling design controlled for produce variations and changes in produce quality over time by collecting tomatoes harvested at two intervals over the growing season, resulting in two sampling periods. Additionally, to control for variations between types of produce, no more than three common varieties of tomatoes were sampled. The varieties selected for study were based on what gardeners are commonly planting and the availability for those varieties at nearby grocery stores. The location of community gardens and potential grocery store sites can be found in Figure 14.

Two separate one-week sampling periods occurred three weeks apart. Sampling occurred as soon as the first batch of tomatoes had ripened and had begun to be harvested by gardeners. The first sampling period coincided with the third week in August 2016 (August 13th to 20th) and the second sampling period followed a few weeks after and covered the first and second week in September 2016 (September 7th to 14th). Produce

was collected upon site visits to community gardens. During each week of collection, garden sites were visited at random, until enough produce (*viz.* three samples per location) had been collected from each garden site.

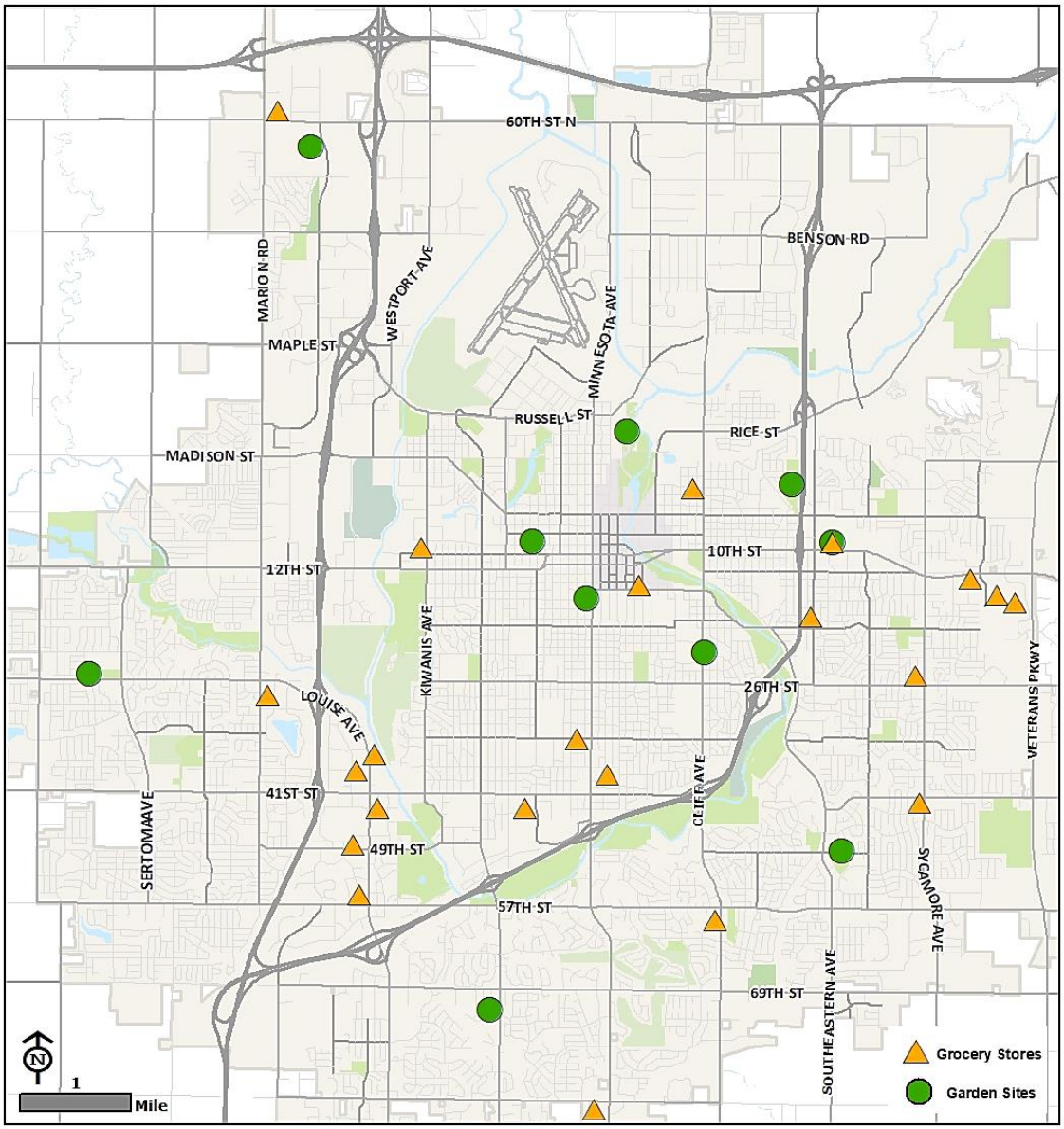

Figure 14: Location of community gardens and grocery stores in Sioux Falls, SD. Data source: City of Sioux Falls 2015 and City of Sioux Falls 2017. Map created by author using ArcMap.

Additionally, for each sampling period, one grocery store that reflected the gardener's closest substitute for fresh produce was selected. Within each store, a sample from the selected varieties, or closest substitute of tomatoes was obtained. If the variety of produce obtained from gardeners was known, the same variety was then obtained at the nearest grocery store. If the variety was unknown, the closest variety in size, shape, and color was obtained to compare. Since there were ten community gardens identified, the goal was to obtain produce from ten community gardens and ten grocery stores. However, only nine sites were used for the first of the two sampling periods. The remaining site was located adjacent to the Avera McKennan Hospital campus, and permission to approach the gardens could not be obtained in time to collect produce for the first sampling period. Thus, nine community gardens and nine grocery stores were used for the first sampling period, and ten community gardens and ten grocery stores for the second sampling period. This sampling procedure resulted in 54 samples for the first sampling period, 60 samples for the second sampling period, rendering a total of 114 samples.

3.4 Data Analysis

3.4.1 Data Analysis: Eating Behaviors

Regarding how urban gardens influence access to fresh produce, nutrition and eating behaviors, a survey was conducted to collect qualitative data of gardener perceptions and experiences. Survey responses were organized into tables, graphs, and charts to help summarize the results and draw conclusions. Multiple choice and yes/no answers were summarized by categories that addressed specific parts of research questions. A majority of survey questions were closed-response, while the open-ended

questions were coded by combining similar themes and ideas and giving those responses their own ‘code’ so the responses were then easier to summarize and analyze. Descriptive statistics were used to analyze the frequency distribution of responses for yes/no and multiple-choice responses from the survey, while inferential statistics were used to test differences and relationships in the data.

3.4.2 Data Analysis: Produce Quality

Laboratory analysis of field-collected produce samples describes the approach used in determining the quality of urban garden produce. Before analysis could be performed, however, samples needed to be prepared. To do so, produce was stored in a cool, dry place until, within a day or two of collection, they were tested for ripeness using firmness and for sugar content using a Brix test. The samples were then dried by a food dehydrator and grounded up for laboratory analysis of micronutrients and macronutrients.

The firmness and Brix analyses were conducted using equipment supplied by the South Dakota State University Geography Department. The equipment used for testing Brix was a Milwaukee Digital Brix Refractometer (Figure 15). Essentially, the higher the reading for the Brix test, the higher the sugar content, which is assumed leads to better taste. Because the Brix refractometer method primarily applies to produce that is ripe, a penetrometer was first utilized to determine the ripeness of each sample. Additionally, the penetrometer was used to measure consistency and variation of ripeness. The penetrometer was an Agriculture Solutions Digital Fruit Firmness Tester (Figure 16). The penetrometer records the pounds of force required to penetrate the flesh of produce. All 114 samples during the two sampling periods were tested with the Brix refractometer and penetrometer. After applying the penetrometer to the store-bought produce and

garden produce, samples underwent ICP-OES analysis to measure micro- and macronutrient content.

Figure 15: Milwaukee Digital Brix Refractometer. Data source: Milwaukee Instruments 2011.

Figure 16: Agriculture Solutions Digital Fruit Firmness Tester. Data source: Agriculture Solutions 2015.

Further nutrient analysis measured the quantity of macronutrients and micronutrient content, with Inductively Coupled Plasma – Optical Emission Spectrometer

(ICP-OES) analysis (a listing of these nutrients can be found in Table 1). To analyze specific nutrient content through the ICP-OES test, 5-10g of each dried and ground up sample were required. Samples were dried through a food dehydrator, and ground into a coarse powder using mortar and pestle as well as a coffee grinder, as needed. The 5-10g of each sample was then delivered to Chris Morris in the Plant Science laboratory at SDSU to go through ICP-OES after microwave acid digestion.

Macronutrients	**Micronutrients**
Phosphorous (P)	Calcium (Ca)
Potassium (K)	Copper (Cu)
	Iron (Fe)
	Manganese (Mn)
	Zinc (Zn)

Table 1: Micronutrients and macronutrients that were collected with ICP-OES analysis.

At a cost of about $12 per sample, a subsample of tomatoes for this analysis was created. Rather than testing tomatoes from all gardens and all stores, three samples from each garden and from each store were combined into one overall sample from each location. For example, from one community garden three samples of tomatoes were collected, but, for the ICP-OES analysis these three samples were combined and mixed into one representative sample. In the first sampling period, there were nine samples from store produce, and nine samples from community gardens, totaling 18 samples. For the second sampling period, there were ten samples collected from both grocery stores and community gardens, totaling 20 samples. Thus, 38 representative samples were analyzed for micronutrients and macronutrients with ICP-OES technology. Further

information on the collection and analysis plan of tomato samples is illustrated in Table 2.

	First Sampling Period		Second Sampling Period		
	Stores	Community Gardens	Stores	Community Gardens	Total
Number of Locations	9	9	10	10	38
Number of Samples	27*	27*	30*	30*	84
Samples to be used with penetrometer	27	27	30	30	84
Samples to be used with refractometer	27	27	30	30	84
Samples to go through ICP-OES analysis	9	9	10	10	38
*3 samples for each location					

Table 2: Data collection and analysis details.

Descriptive statistics were used to analyze the frequency distributions as well as measures of spread and central tendency of the nutrient levels from the laboratory analysis between garden and store produce, while inferential statistics were used to test differences and relationships in the data. Additionally, laboratory data were organized in to tables, graphs, and charts to summarize the results.

CHAPTER 4. RESULTS AND DISCUSSION

In response to growing concerns of nutrition, access, and availability of fresh produce, this study aims to shed light on the role of urban gardens in combatting food insecurity. The following results are the culmination of qualitative data obtained from the online survey, and quantitative laboratory analysis conducted on produce obtained from gardens and grocery stores. Additionally, this section summarizes the answers to the research questions and discusses the broader contributions of this research.

4.1 Results

4.1.1 Results: Eating Behaviors

The first research objective, related to gardeners' eating behaviors, involved the use of a survey instrument to collect information about eating behaviors from a sample of 60 community gardeners across the study area. The survey was distributed online and collected information on demographics, motivations, access, diets, and nutrition to better understand the relationship between gardeners and perceptions of food security.

Although not initially part of the study objectives, questions were asked to obtain some characteristics and information about those completing the survey. These questions showed the gardeners completing the survey to be highly experienced and highly educated, as 43 (72%) had obtained a bachelor's degree or higher (Figure 17) and 38 (63%) had at least five years of experience with gardening (Figure 18).

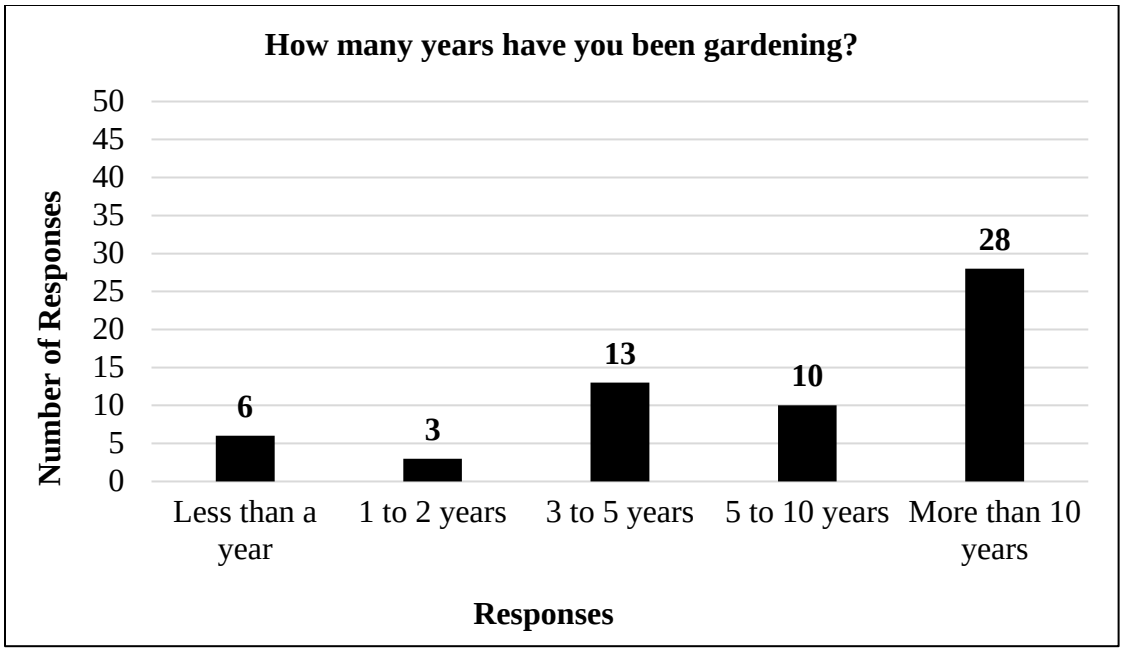

Figure 17: Frequency distribution of the number years gardeners have been gardening.

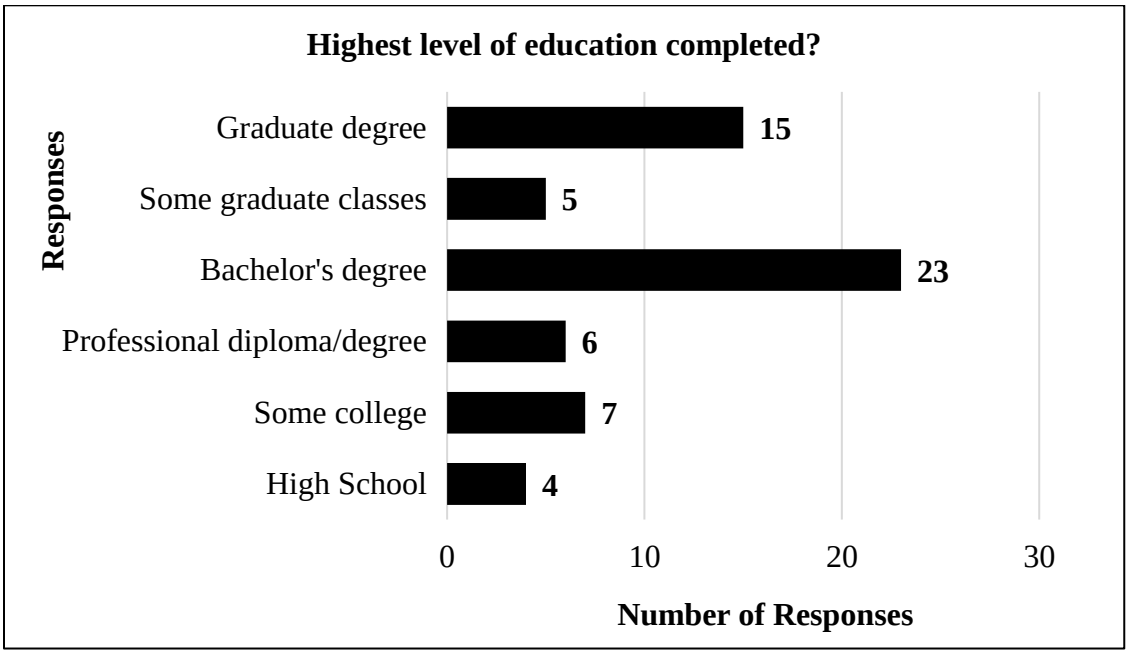

Figure 18: Frequency distribution of the highest level of education completed by gardeners.

A primary goal of the survey was to capture gardening motivations. Gardeners had a wide variety of responses for their primary reason to garden. One of the leading reasons, at 20%, was to improve diets. Similarly, nine respondents reported reconnecting

with nature as their primary reason (Figure 19). In addition, 21 gardeners answered with "other" and provided their response in free text. These 21 responses and how they were categorized is illustrated in Appendix B. Of the 21 gardeners to enter a free-text response, four entered responses related to access. These four responses were added to the original responses of nine who answered gardening as a response to low access to fruits and vegetables; this put the total responses at 13 (21.67%) for gardening to improve access. Other noticeable reasons included taste, to lower grocery bill, and as a hobby.

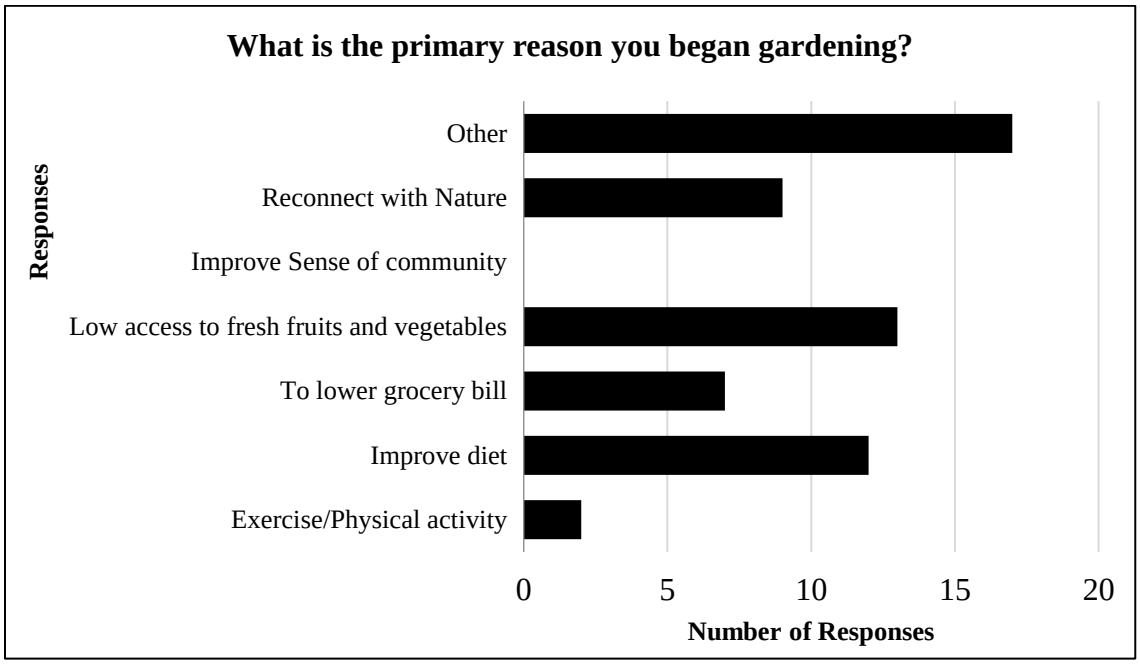

Figure 19: Frequency distribution of the primary reason gardeners began gardening.

Gardeners were asked a few questions related to access of nutritional food. When asked if they felt they had better access to fresh fruits and vegetables because they gardened, 56 (93.3%) gardeners responded affirmatively (Table 3). They were also asked where they obtained their produce other than their garden. This question was initially created to gather responses on specific stores and the location of that store. Ideal responses would have been "Hy-Vee at 1900 S Marion Rd", but ultimately the question

was worded too broadly to allow such a response. Nearly every response involved "grocery store", but many other answers appeared, such as farmer's market, food Co-Op, and Community Supported Agriculture (CSA), and combinations of these responses. Responses also mentioned the names of stores utilized such as Wal-Mart, Hy-Vee, Aldi, Costco, and Fareway, but no specific locations were given. A table showing how these responses were categorized can be found in Appendix C, and the result of these categorizations is illustrated in Figure 20.

Do you feel you have better access to fresh fruits and vegetables because you garden?
56 Yes 4 No
Does your diet contain more nutritious food because you garden?
53 Yes 6 No
Do you eat more fresh fruits and vegetables since you began gardening?
49 Yes 11 No
If you eat more fresh fruits and vegetables since you began gardening, do you eat more fresh fruits and vegetables all year long?
36 Yes 13 No
Do you grow more food than you can use?
42 Yes 18 No

Table 3: Responses to yes/no survey questions.

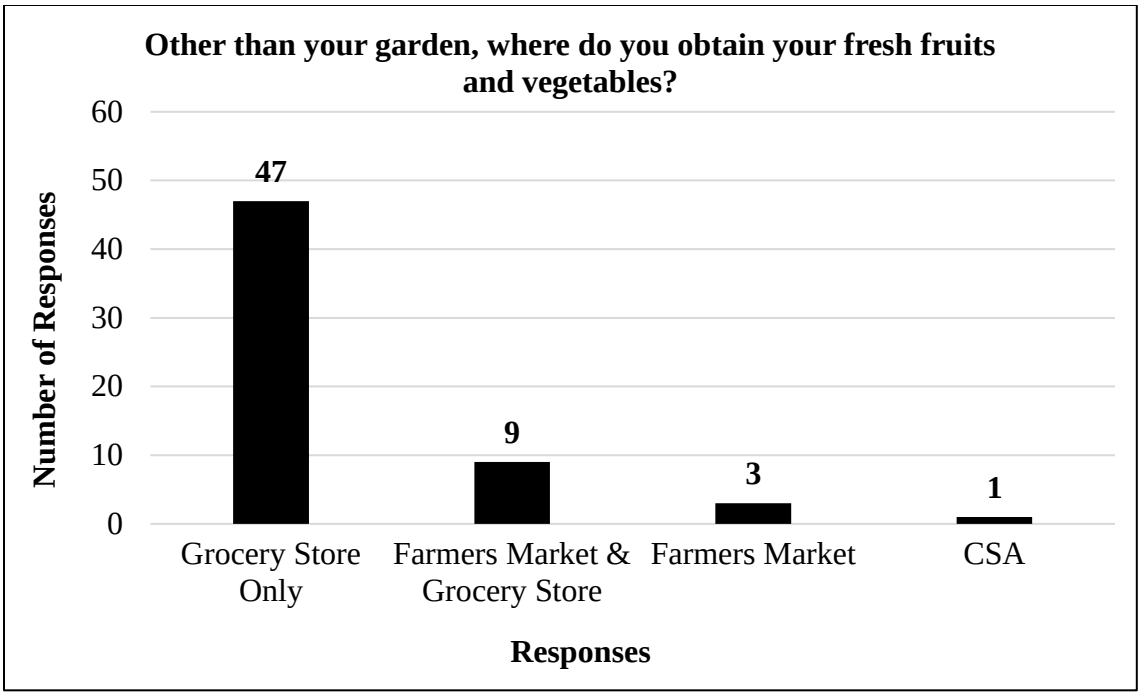

Figure 20: Frequency distribution of where gardeners obtain their fresh fruits and vegetables.

Following questions on access, gardeners were questioned on changes to their purchasing patterns. When asked if they ate more fruits and vegetables from their garden or from the store, a majority responded with "from the store" (Figure 21). In the ensuing question, those who responded, "my garden" were asked to comment on why they ate more fruits and vegetables from their garden. Although only 23 gardeners selected "my garden", 36 answered the following question. Of those 36, the leading answers were due to taste, availability, and affordability (Figure 22).

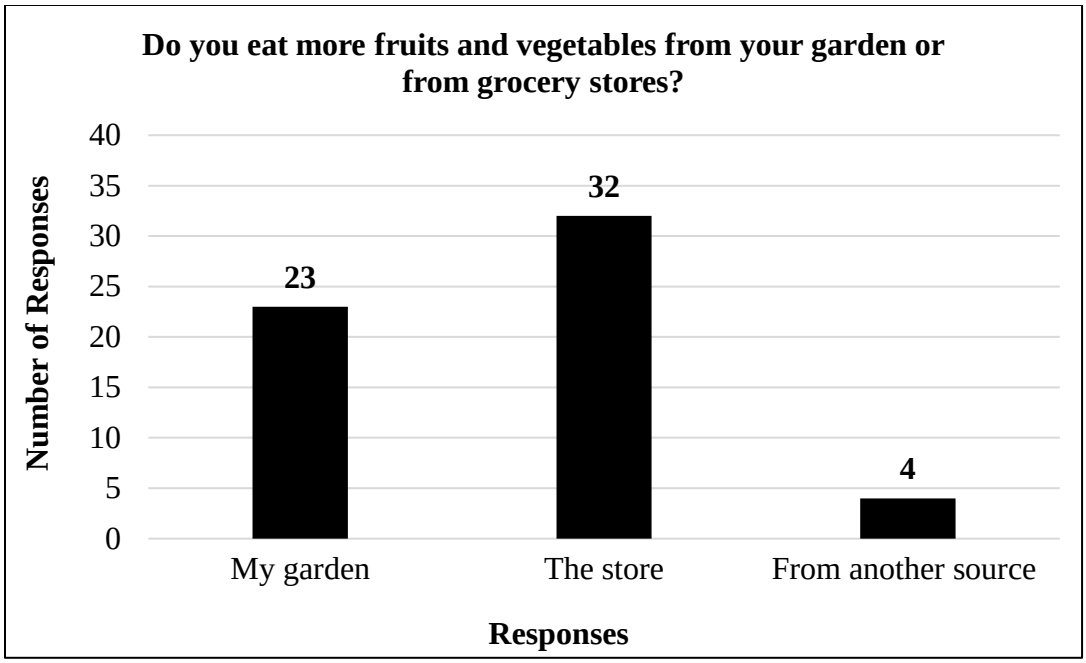

Figure 21: Frequency distribution of whether gardeners eat more fruits and vegetables from their garden or from grocery stores.

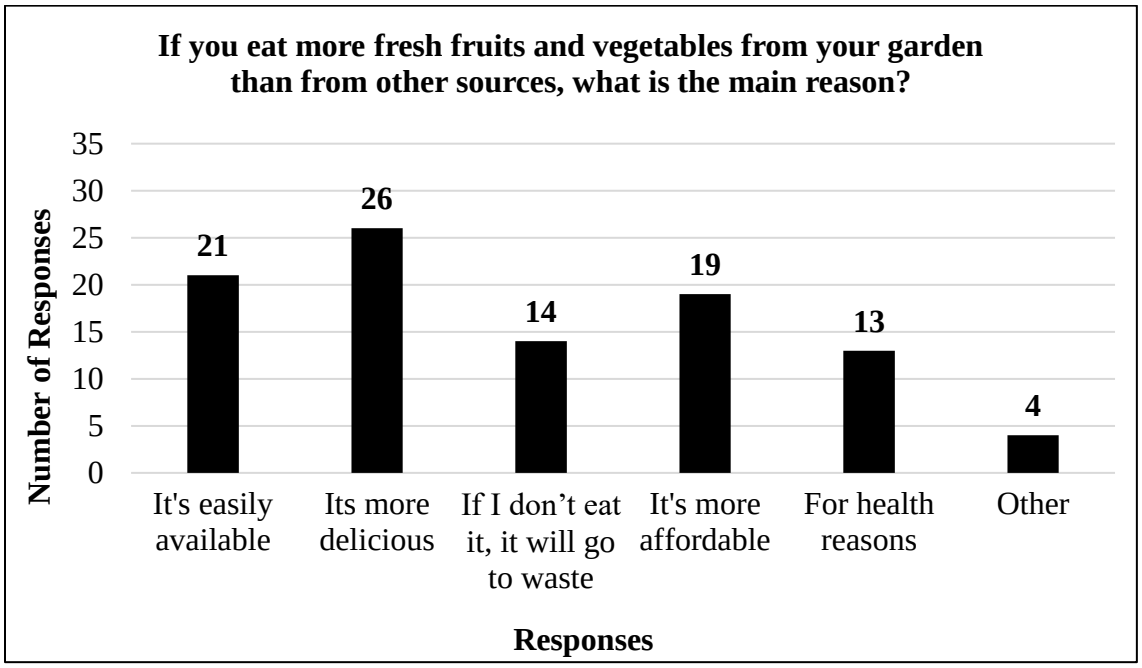

Figure 22: Frequency distribution of why gardeners eat more fresh fruits and vegetables from their garden than from other sources.

Gardeners also noted changes to their diet, as 53 (90%) answered yes to having a diet that contains more nutritious food because they garden. Similarly, 49 (82%)

gardeners claimed to eat more fruits and vegetables since they initially began gardening. This shift towards eating more fruits and vegetables was true all year round for 37 (76%) gardeners. Answers to these yes/no questions can be seen in Table 3.

Diets were further measured when asking, "How many servings of fruits and vegetables do you eat per day?" At the two extremes, one person (2%) responded to eating less than one serving, while 16 (27%) gardeners claimed to eat five or more. A majority of responses landed in-between with 21 gardeners (35%) responding with one to three servings and 22 (37%) responding with three to five servings (Figure 23). Lastly, gardeners were asked if they grow more food than they can use for themselves, with 42 (70%) answering yes (Table 3). Of those 42, when asked what they did with the surplus, 25 (60%) answered with distributing to friends and family. Others answered with either donating produce or canning, and none responded that they sold their produce (Figure 24). (See Appendix A for the entire list of survey questions along with the distribution of responses.)

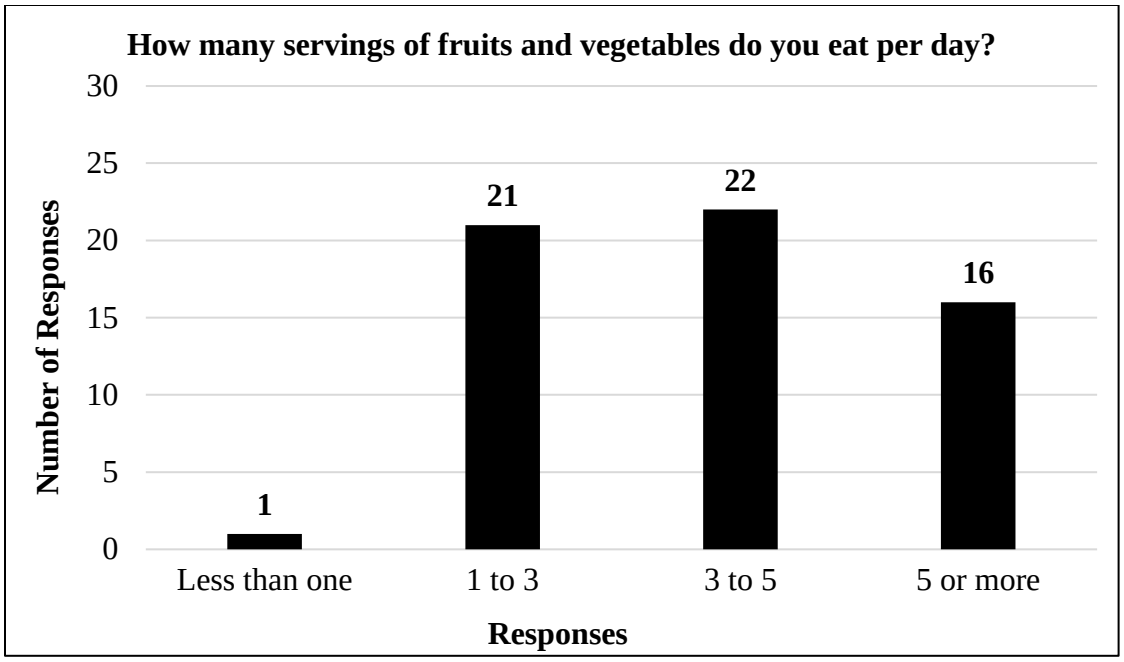

Figure 23: Frequency distribution of how many servings of fruits and vegetables eaten per day. (One serving is equivalent to 1/2 cup of green beans or 1/2 a medium apple.)

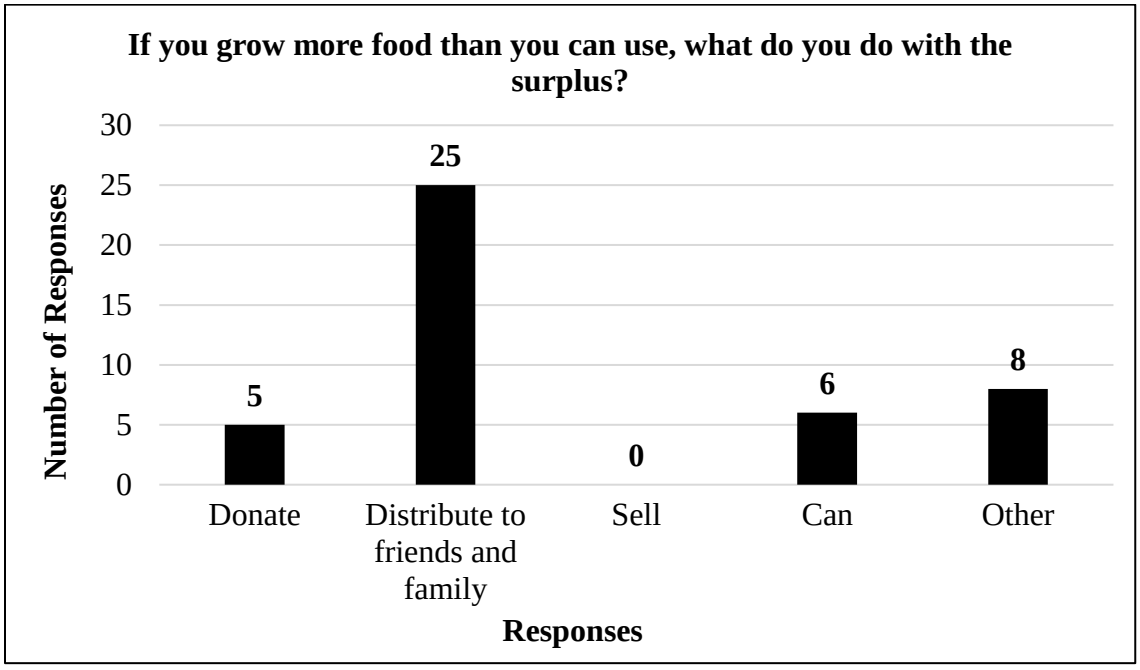

Figure 24: Frequency distribution of what gardeners do with surplus food.

4.1.2 Results: Produce Quality

The second objective aimed to examine connections between Sioux Falls gardens, gardeners and their impacts on local health metrics. This was performed by comparing the sugar content and nutrient levels between garden produce and store-bought produce. Two sampling periods occurred, three weeks apart. The variety of produce and the gardens and stores that were compared for each sampling period can be found in Appendix D. While the locations of gardens and their store equivalent for each sampling period can be seen in Figure 25 for the first sampling period, and Figure 26 for the second sampling period.

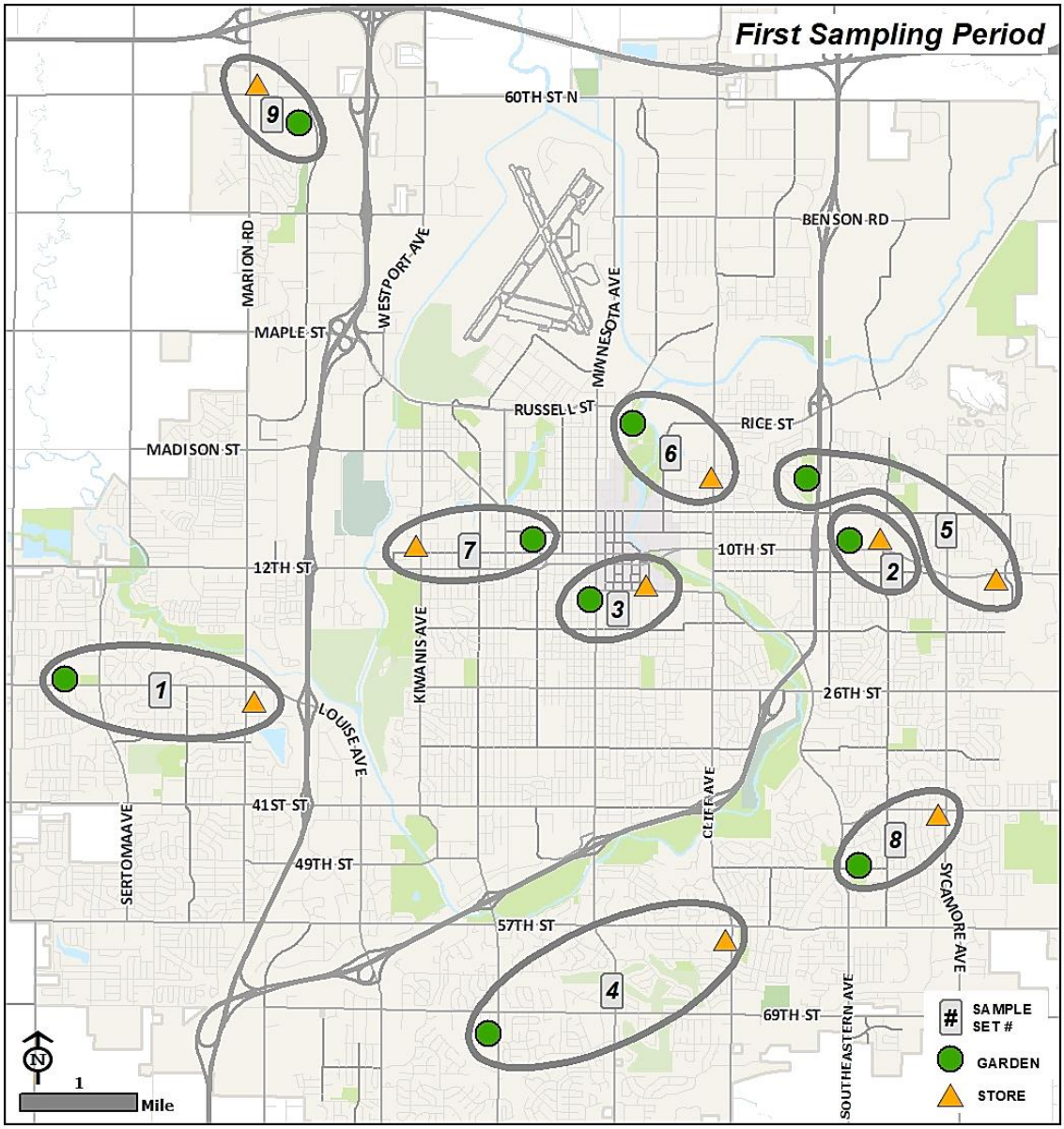

Figure 25: Location comparison for garden and store produce for the first sampling period. Sample set numbers correspond to Appendix D. Data source: City of Sioux Falls 2015 and City of Sioux Falls 2017. Map created by author using ArcMap.

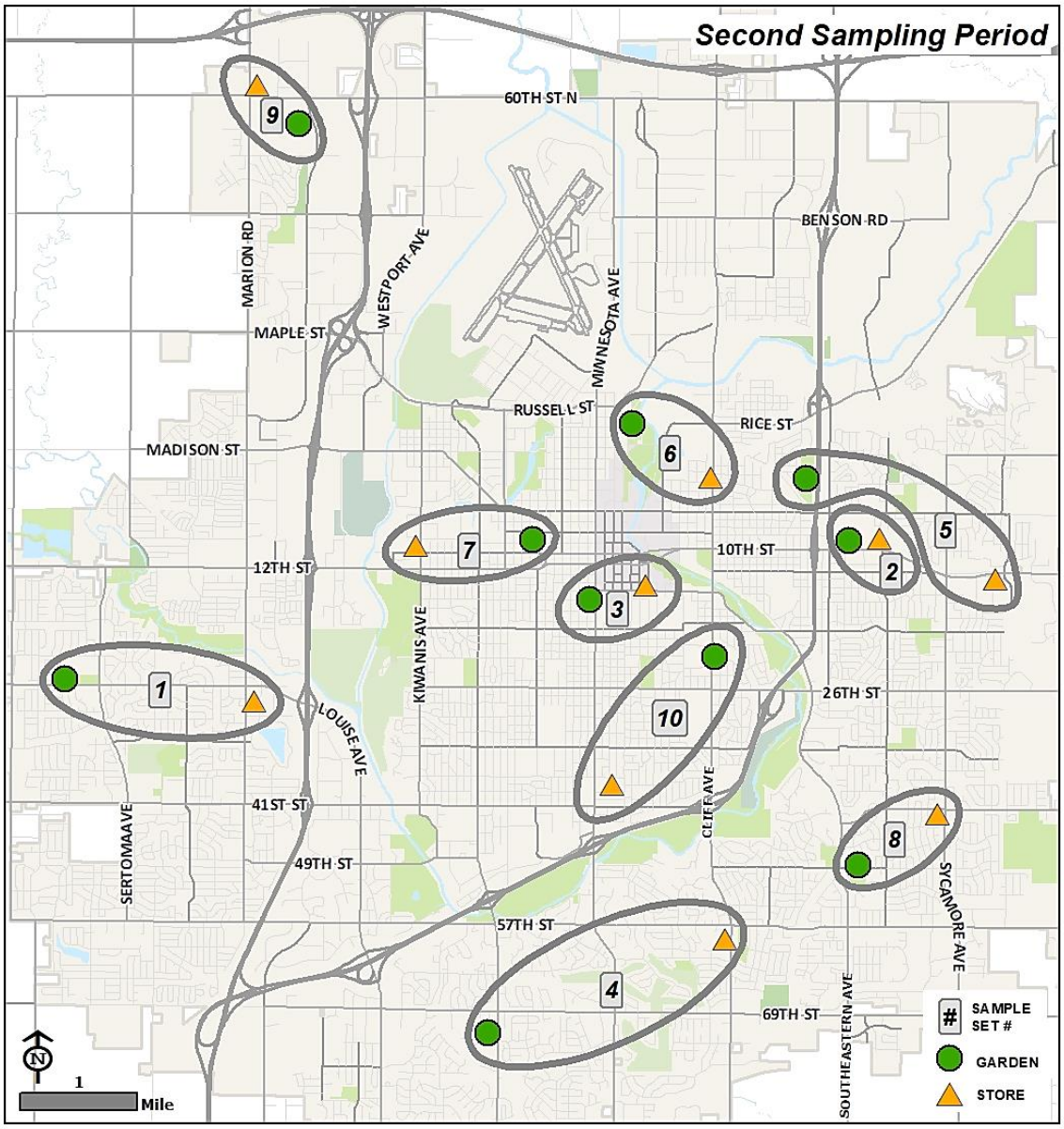

Figure 26: Location comparison for garden and store produce for the second sampling period. Sample set numbers correspond to Appendix D. Data source: City of Sioux Falls 2015 and City of Sioux Falls 2017. Map created by author using ArcMap.

After produce were collected, the first tests performed were to measure firmness, using a penetrometer, and sugar content, using a Brix Refractometer (see Appendix E for a full listing of firmness and sugar content test results). For Brix, measurements are described in percent (%) Brix and represent the sugar concentration within the juice of

the tomato. For the first sampling period, the tomato Brix level for garden tomatoes ranged from 3.7% to 8.9%, while Brix levels for store bought tomatoes ranged from 3.1% to 5.4%. In the second sampling period, garden Brix levels ranged from 3.9% to 8.8%, and 3.0% to 7.3% for store tomatoes. Over the course of two periods, Brix levels averaged 5.8% for garden tomatoes, and 4.5% for store tomatoes. Additional descriptive statistics can be seen for each sampling period and combined statistics for all sampling periods in Table 4. Firmness readings from the penetrometer were recorded in pounds (lb.) and represent the amount of pressure present when penetrating a sample. Firmness levels for the first sampling period had a mean of 2.6 lbs. for garden tomatoes, and 3.0 lbs. for store tomatoes while mean firmness for the second sampling period were 2.4 lbs. for garden tomatoes and 3.1 lbs. for store tomatoes. The full set of descriptive statistics for firmness can be found in Table 5.

Brix (% Brix)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	3.7	3.1	3.9	3.0	3.7	3.0
Max	8.9	5.4	8.8	7.3	8.9	7.3
Mean	5.6	4.4	5.9	4.6	5.8	4.5
Median	5.4	4.5	5.5	4.2	5.5	4.3
Mode	5.2, 5.6	4.8	6.3	3.7, 4.3	5.2	4.8
Standard Deviation	1.1	0.7	1.2	1.3	1.1	1.0
Range	5.2	2.3	4.9	4.3	5.2	4.3

Table 4: Brix test results: Descriptive statistics for the first and second sampling periods.

Firmness (lbs)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	1.3	0.8	1.1	1.2	1.1	0.8
Max	3.8	5.0	3.6	5.7	3.8	5.7
Mean	2.6	3.0	2.4	3.1	2.5	3.0
Median	2.6	2.8	2.4	3.0	2.5	2.9
Mode	2.6, 3.3, 2.8	N/A	2.1	3, 2.4	N/A	N/A
Standard Deviation	0.6	1.1	0.6	0.9	0.6	0.1
Range	2.5	4.2	2.5	4.6	2.8	5.0

Table 5: Firmness test results: Descriptive statistics for the first and second sampling periods.

A two-tailed unpaired *t*-test, assuming equal variance, was conducted to determine the significance of the differences between means in garden and store produce quality. For all subsequent *t*-tests, this study assumed equal variance and used an alpha level of 0.001. The differences in the means for Brix and ripeness tests proved to be significant in both cases. Table 6 shows the results of the *t*-test and the values used to determine significance.

Variable	**Garden Produce Mean**	**Store Produce Mean**	**Calculated *t***	***p*-value**
Brix (%)	5.76	4.50	6.11	<0.001
Ripeness (lbs)	2.53	3.02	3.22	0.002

Table 6: Results of *t*-test for Brix and ripeness showing calculations of the statistical significance between the means of garden and store produce quality.

The next step was to determine the nutritional quality of garden produce compared to store bought produce. This was performed using ICP-OES analysis, which measured micro and macronutrients. As mentioned previously, all three tomato samples were combined into one set for each location. Store produce generally had higher macronutrient values, as the average amount of potassium and phosphorous found in store produce was higher than garden produce. This was also generally true for the micronutrients tested as well. Copper was the only nutrient tested that had a mean value higher for gardens (10.5 ppm) than grocery stores (10.2 ppm). Nutrients of grocery store produce also tended to vary more. The ranges and standard deviations for store produce were always higher or equal to garden produce samples. Additionally, descriptive statistics for both sampling periods comparing macronutrients of gardens and stores can be found in Table 7 and the results showing the full set of descriptive statistics for micronutrients in Table 8. See Appendix F for a complete listing of nutrients for all garden and store locations.

K%

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	3.11	3.17	2.76	3.15	2.76	3.15
Max	3.68	4.71	3.63	4.2	3.68	4.71
Mean	3.36	3.72	3.34	3.6	3.35	3.66
Median	3.31	3.47	3.43	3.6	3.39	3.47
Standard Deviation	0.17	0.49	0.28	0.39	0.24	0.44
Range	0.57	1.54	0.87	1.05	0.92	1.56

Table 7 Continued

P%

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	0.245	0.303	0.254	0.29	0.245	0.29
Max	0.387	0.479	0.45	0.548	0.449	0.548
Mean	0.314	0.387	0.324	0.396	0.32	0.392
Median	0.303	0.406	0.297	0.378	0.303	0.385
Standard Deviation	0.04	0.06	0.07	0.07	0.06	0.06
Range	0.142	0.176	0.195	0.258	0.204	0.258

Table 7: ICP-OES Macronutrients - Descriptive statistics for the first and second sampling periods.

Zn (ppm)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	11.8	13.5	11.9	11.2	11.8	11.2
Max	19.6	19.8	24.4	24.1	24.4	24.1
Mean	13.9	16	15.6	14.7	14.8	15.3
Median	13.4	16.2	14.4	13.1	13.4	14.9
Standard Deviation	2.3	1.8	3.6	3.9	3.1	3.1
Range	7.8	6.3	12.5	12.9	12.6	12.9

Fe (ppm)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	22.3	30.5	21.9	21.7	21.9	21.7
Max	42.8	46.1	42	50.8	42.8	50.8
Mean	30.5	38.3	32.7	35.7	31.7	36.9
Median	30.1	37.8	32.4	36.5	30.8	37.3
Standard Deviation	5.9	5.1	5.8	8.8	5.9	7.4
Range	20.5	15.6	20.1	29.1	20.9	29.1

Table 8 continued

Mn (ppm)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	3.3	3.6	2.4	3.9	2.4	3.6
Max	5.5	15.4	6.5	15.6	6.5	15.6
Mean	4.5	8.7	4.7	8.4	4.6	8.5
Median	4.6	7	4.8	6.6	4.7	6.8
Standard Deviation	0.6	4	1	3.6	0.9	3.8
Range	2.2	11.8	4.1	11.7	4.1	12

Cu (ppm)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	8	5.1	6.9	5.5	6.9	5.1
Max	13.8	18.2	16.2	22.4	16.2	22.4
Mean	10.1	10.1	10.9	10.2	10.5	10.2
Median	9	9.6	9.9	9.1	9.6	9.6
Standard Deviation	2	3.4	2.7	4.7	2.4	4.1
Range	5.8	13.1	9.3	16.9	9.3	17.3

Ca (%)

	First Period		Second Period		Overall	
	Gardens	Stores	Gardens	Stores	Gardens	Stores
Min	0.04	0.06	0.05	0.08	0.04	0.06
Max	0.19	0.19	0.17	0.21	0.19	0.21
Mean	0.11	0.14	0.11	0.14	0.11	0.14
Median	0.1	0.15	0.11	0.13	0.1	0.13
Standard Deviation	0.04	0.04	0.03	0.04	0.04	0.04
Range	0.15	0.13	0.12	0.13	0.15	0.15

Table 8: ICP-OES Micronutrients - Descriptive statistics for the first and second sampling periods.

A two-tailed unpaired *t*-test was conducted to determine the significance of differences between means of produce nutrition. While mean values were higher for all store produce compared to garden produce, except copper, the test showed significance for only manganese and phosphorous. Additionally, *t*-test results showed no significant

difference in the means for zinc, copper, and calcium, iron and potassium. Table 9 shows the results of the *t*-test and the values used to determine significance of mean difference for nutrients in garden and store produce.

Variable	Garden Produce Mean	Store Produce Mean	Calculated *t*	*p*-value
Micronutrients				
Zn (ppm)	14.81	15.33	0.45	0.627
Fe (ppm)	31.66	36.93	2.36	0.024
Mn (ppm)	4.62	8.53	4.30	<0.001
Cu (ppm)	10.52	10.15	0.33	0.744
Ca (%)	0.11	0.14	2.00	0.053
Macronutrients				
P (%)	0.32	0.39	3.60	0.001
K (%)	3.35	3.66	2.58	0.014

Table 9: Results of *t*-test for nutrient content showing calculations of the statistical significance between the means of garden and store produce quality.

4.2 Discussion

4.2.1 Discussion: Eating Behaviors

The first objective investigated eating behaviors of gardeners through surveys. To this end, the following research questions addressed the first objective. What motivations led community members to begin gardening? There was quite a variety of responses regarding gardening motivations that led community members to begin gardening, but the top two most reported responses by gardeners were directly related to three primary aspects of food security mentioned previously in the review of literature; access, availability, and utilization. A surprising number of participants listed “low access to fresh fruits and vegetables” as their primary reason for gardening. This trend seems

incongruous with Sioux Falls, where a majority of the city does not fall into the conventional definition of a food desert (low income tracts that also have at least 33% of the population residing more than one mile from a grocery store), although there are some large areas that do qualify as food deserts (Figure 27).

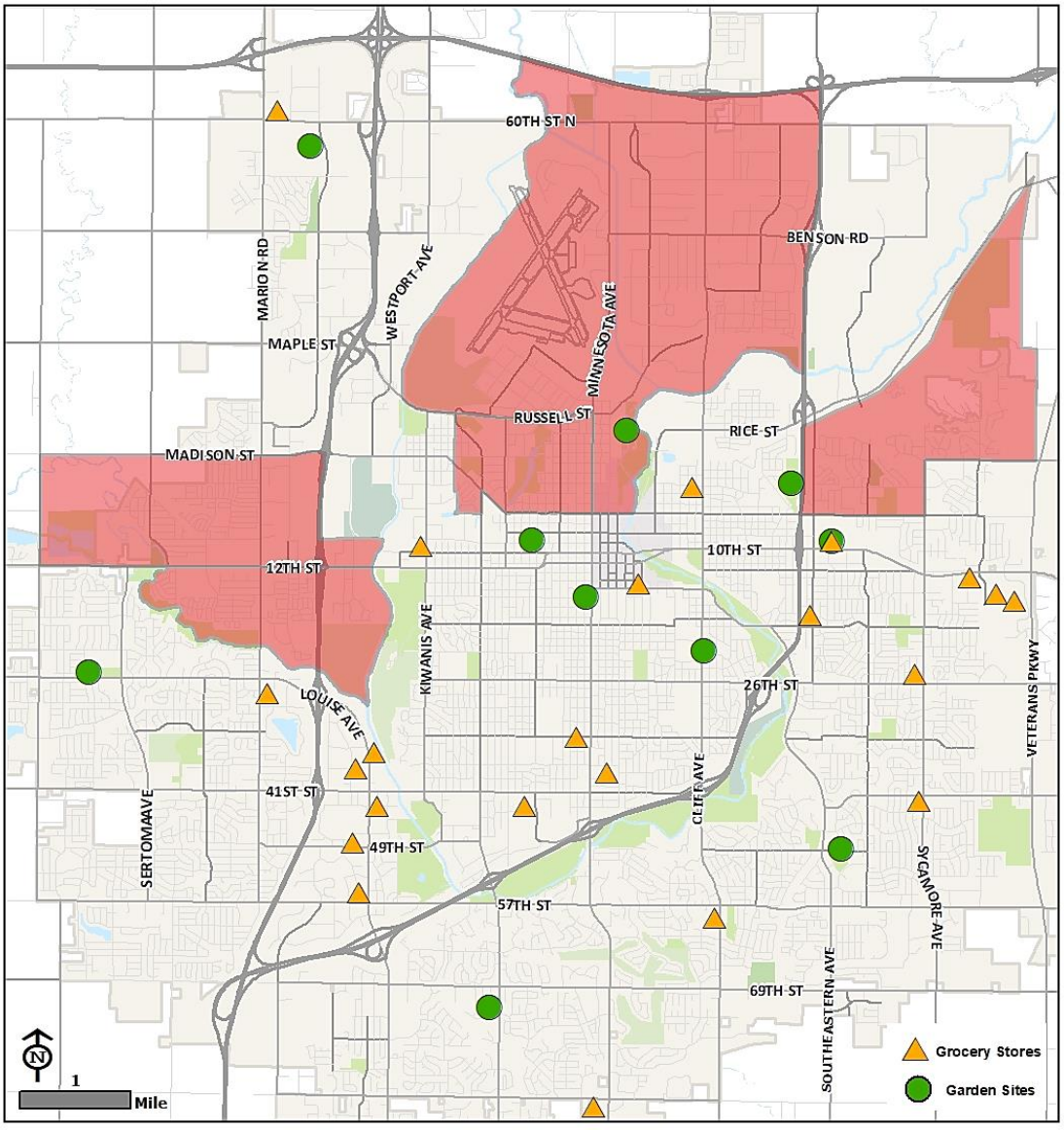

Figure 27: Community gardens and grocery stores with one-mile food desert definition. Shaded areas indicate census tracts flagged as food deserts. (Low-income tracts that also have at least 33% of the population residing more than one mile from a grocery store). Data source: ERS 2017 and City of Sioux Falls 2017. Map created by author using ArcMap.

However, access could have been chosen due to poor variety options at the locations where their produce is obtained, or due to not living within a perceived accessible distance from grocery stores and fresh produce. Next, as is consistent with health concerns previously mentioned in the study across the country, state, and city, gardeners claimed "improving diets" as their primary motivation for gardening. This motivation connects with the utilization aspect of food security, as gardener's use of their produce is to improve their diets.

A large number of gardeners used free responses to convey their motivations including gardening as a hobby, which accounted for 15% of all responses. The final few motivations that garnered considerable response, were gardening due to better produce taste and to lower grocery bills. Reflecting on the different aspects of food security, taste, to some extent, also ties in with utilization, in the sense that tastier produce means consumers are more likely to eat that produce, resulting in an increase in produce consumption.

How have urban gardens impacted access to nutritional food? Access to nutritional food is one of the four aspects of food security. As addressed above, when asked about gardening motivations, several gardeners' primary reason for gardening was to improve their access to nutritional food. When directly asked if gardening resulted in better access to nutritional food, an overwhelming majority of gardeners indicated that it did. This observation shows a direct, positive influence of community gardens on perceptions of food security.

How have food-purchasing patterns changed? Gardener responses on purchasing patterns shed additional light on perceptions of food security. While most respondents

noted that they ate more fruits and vegetables from their garden than from the store, their reasons were related to food security. These reasons were taste, availability, and affordability. Again, taste connects to the aspect of food security of utilization, in that tastier food means more consumption. Availability was mentioned and is one of the aspects of food security. Lastly is affordability, which relates to the aspect of access in that when growing one's own produce is more affordable, nutritional food is more available and accessible.

How have diets changed since beginning to garden? How many servings of fruits and vegetables do gardeners, their family members, and community members eat daily? Is this only a seasonal shift (purchasing patterns) or does the change last year-round? The above questions relate to gardener's perceptions of utilization, or the aspect of food security that is concerned with how or what people are eating. These questions, related to diets and what gardeners are eating clearly show a link between the act of gardening and a person's consumption of fruits and vegetables. A majority of gardeners indicate that they are eating more produce since gardening (89.8%), and many gardeners claim to have more nutritious diets overall because of gardening (81.7%). Additionally, of those gardeners who eat more fruits and vegetables since they began gardening, most are not just eating more during the gardening season, but during all times of the year they claim to be eating more healthy options (74%).

Although it is dealing with a smaller sample size, the belief that gardens positively influence health is further reinforced by the number of servings of fruits and vegetables eaten by gardeners. Previously, this study mentioned that as of 2009, only 12.6% of Sioux Falls residents and 15.7% of South Dakota residents eat the

recommended five or more servings of fruits or vegetables a day, while the nationwide median is 23.5%. As mentioned in the review of literature, this recommendation of five or more servings of fruits and vegetables a day was set in the 2005 Dietary Guidelines for Americans, by the HHS. Comparatively, 27.0% of the respondents in this study claimed to eat five or more servings (Figure 28), which suggests that gardeners appear almost twice as likely to meet the HHS guidelines.

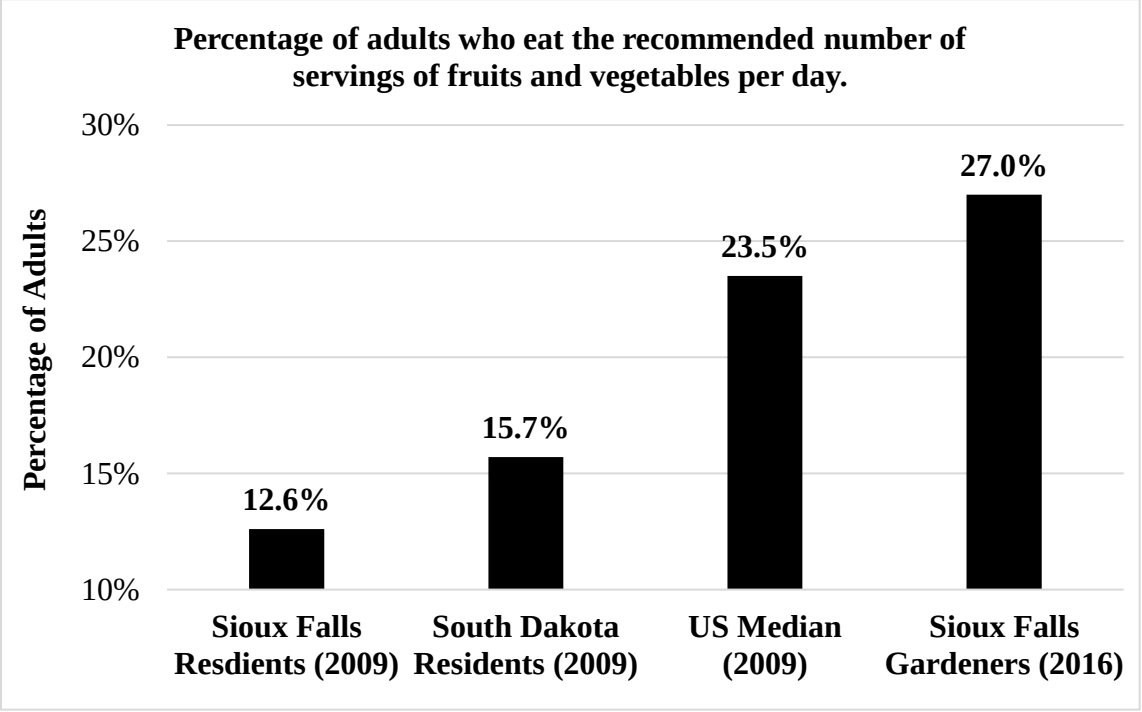

Figure 28: Percentage of adults who eat the recommended number of servings (5 or more) of fruits and vegetables per day. Data source: Community Health Status Report 2012 and this study.

Lastly, discussing utilization and how gardeners use the produce they grow, respondents were most likely to distribute to friends and family (65.8%), can (15.8%), or donate their excess produce (13.2%) (Figure 24). While no gardeners stated their primary motivation was to connect with the community, those gardeners with excess may be inadvertently strengthening or improving connections with their communities and

those around them. Based on responses about diets and consumption of fruits and vegetables, the simple act of gardening seems to have a positive and lasting influence on Sioux Falls gardeners' perceptions of their overall health.

4.2.2 Discussion: Produce Quality

A comparison of nutritional content and taste quality between community gardens and grocery stores was used to quantify produce quality. The following questions were answered to address the second objective related to produce quality.

What is the nutritional quality of store-bought produce compared to community gardens? ICP-OES analysis measured micro and macronutrient values. For macronutrients, the ranges of both potassium and phosphorus were consistent, while the actual values tended to be slightly higher for grocery stores. This general pattern also held true for micronutrients of zinc, iron, manganese, and calcium. However, based on the results of an unpaired *t*-test, the difference between garden and store produce was only significant for manganese and phosphorous. Values for store-bought tomatoes were slightly more inconsistent as ranges were higher for all but calcium. However, copper was the only nutrient where gardens had a higher average nutrient value. While the ranges of grocery store produce may have been more inconsistent, when obtaining fruits and vegetables gardeners may find a similarity in nutrient levels between store-bought and garden produce. Additionally, soil practices and nutrient management practices may affect these values, but measuring these variables was outside the scope of this study.

Does fresh garden produce have higher Brix levels than store bought produce? As discussed previously, the Brix refractometer measured sugar content, and was used to determine taste quality of produce. Brix levels came out largely in favor of garden

produce. While the ranges were higher for garden produce in both sampling periods, the sugar content consistently was higher for all but a few comparison sites. Having a high Brix level is noteworthy, as mentioned in this study's methods, due to better tasting produce leading to an increase in produce consumption. Pearson correlation coefficients were used to determine the statistical association between firmness and sugar content for both sampling periods. However, the strength of the association was found to be negative and weak for both the first sampling period (r = 0.28) (Figure 29) and the second sampling period (r = -0.22) (Figure 30). This association meant sugar content and firmness could be tested independently. Therefore, firmness, measured via penetrometer, in the case of this study served to show consistency in obtainable produce. In this study, it was assumed that when produce was obtained from grocery stores it would be obtained in a ripened state. Thus, standard deviations and ranges were examined, in the sense that higher ranges and standards deviations meant produce ripeness was less consistent.

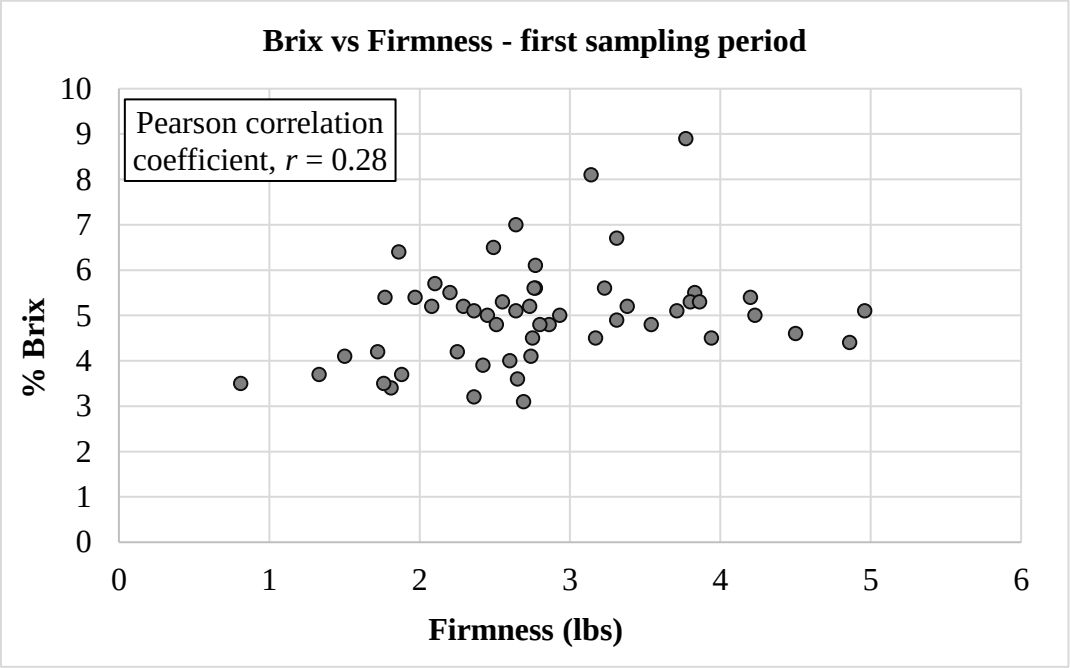

Figure 29: Scatterplot and Pearson correlation coefficient for firmness against Brix for the first sampling period.

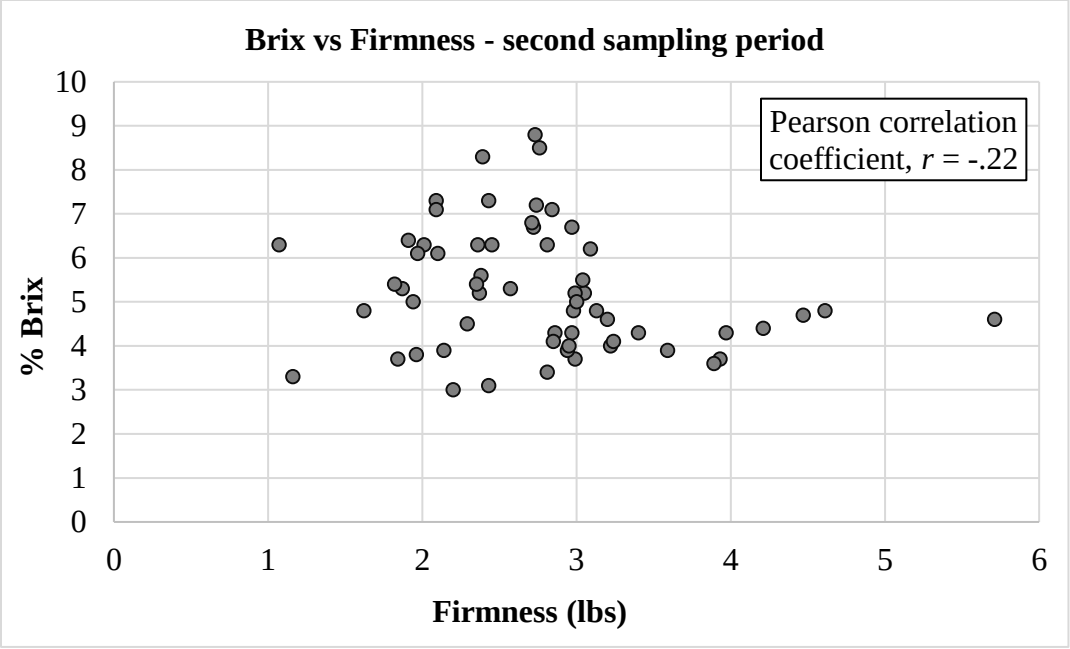

Figure 30: Scatterplot and Pearson correlation coefficient for firmness against Brix in the second sampling period.

Given that garden produce was more consistently ripe, consumers have control to determine when a fruit or vegetable is ready to be picked. In sum, as a measure of tastiness, Brix levels of garden produce illustrate that if gardeners want the best tasting produce, and the ability to better control ripeness of produce, they are better off growing it themselves. Additionally, for the differences between the means of garden and store produce, an unpaired *t*-test showed the differences to be significant for both sugar content and ripeness.

Connections can be made between produce quality and eating behaviors of gardeners. While nutritional content levels were comparable between garden and store produce, the survey showed people ate more from their garden than from stores when available. This increased consumption is likely the result of garden produce tasting better than store produce and being more readily available. Furthermore, a large number of gardeners who responded to the survey claimed to eat the recommended servings of fruits

and vegetables at a rate higher than the rest of the country, again likely due to garden produce tasting better than store produce.

4.3 Study Limitations

There were several limitations in this study. First, the sample size of the study could have been greater to get a more complete view of gardening perceptions throughout the city. Around 60 gardeners were surveyed, out of the estimated 250 or so gardeners in the city. The discussion of results also assumed that all respondents answered honestly and truthfully, and that the sample population was a representative group of the entire gardening population. If time and resources would have allowed, one way to improve this could have been to manually deliver surveys to gardeners in person, mail surveys out, or include other members of the community as well. Additionally, since surveys were only distributed via email, the survey was likely limited to those who owned a computer or had access to the internet. There were also questions that could have been added to improve the survey. Open-ended questions regarding where gardeners obtain their produce led to many vague answers. It would have been more beneficial to get the exact address or location of where respondents obtained their produce, as well as the specific community garden a gardener's plot was located. Knowing specific garden locations could then have helped better identify what grocery stores to use as comparison sites when analyzing produce quality in the second objective.

The study was limited in that there was not an optimal way to control for diversity in tomato variety. When approached, many gardeners did not know what variety of tomatoes they had planted, which then made it difficult to locate comparable tomato varieties in the stores. There was also general difficulty in locating gardeners, as

individual sites were visited at random and varying hours of the day. Thus, finding gardeners, and gardeners willing enough to share their produce, limited the ability to accept tomatoes of a limited variety. Thus, comparisons between produce may also have been skewed, as true comparisons of tomato varieties could not be found when gardeners did not know their tomato varieties. Lastly, grocery stores were chosen by proximity to gardens; choosing stores by proximity to gardens assumed that all gardeners live near the community garden in which they garden, when in fact some sites may be more popular than others, gardeners may actually shop for produce near school or work, and gardeners may need to travel long distances to get from their home to garden.

CHAPTER 5: CONCLUSIONS

This case study examined the relationship between the utilization aspect of food security and community gardens in Sioux Falls, and addressed research questions regarding gardening motivations and eating behaviors, as well as comparing nutritional quality between garden and store produce. According to the results from this study, Sioux Falls gardeners view gardening as important to improving their nutrition and enhancing their diets. Additionally, while gardener's report positive perceptions on gardening and its impact on food security, no meaningful difference in nutritional content was found between store produce and garden produce. However, garden produce appeared to be more nutritionally consistent, and have a better taste than store produce, meaning gardeners and other consumers of garden produce will be more likely to eat the tastier produce and have a more favorable outlook on eating foods related to a healthy diet. In conclusion, this study showed that in Sioux Falls, gardener experiences, and the contents of their produce, positively coincide with improved nutrition and feelings of being food secure.

As this study previously stated, there are four dimensions of food security described by the FAO, access, availability, utilization, and time. While the utilization and nutrition aspects were the primary concern of this study, access, availability, and utilization were all addressed when examining eating behaviors of gardeners. The dimension of access, identified earlier as the income, expenditure, and buying capacity of individuals, was mainly acknowledged when discussing gardening motivations. Improving access was the number one reason gardeners listed as their reason for gardening. Gardeners also noted that they felt gardening gave them better access to

produce, and that this improved access led them to eat more produce. Availability, or the supply of food, was briefly acknowledged as a reason that gardeners eat more produce since gardening made produce more obtainable, and thus more affordable.

The final aspect the survey touched on was utilization, or how produce is "used" by consumers. Motivations related to utilization included improving diets and to have better tasting produce. These answers appeared again when gardeners described reasons for eating more produce, improving diets, and for better taste. Utilization is also impacted when gardeners choose to distribute or donate their excess produce, thus increasing utilization to the surrounding community. Lastly, gardeners appear to have a higher rate of fruit and vegetable consumption than others in the city, state, and nation. These responses related to utilization show that gardening plays a beneficial role on nutrition and food security.

The qualitative approach of this study primarily examined items pertaining to gardening motivations, access, purchasing patterns, and dietary changes. The responses of perceptions of gardeners suggest that the experience of gardening provides a strong and positive impact on the aspects of food security in the lives of gardeners. Additionally, quantitative analysis showed that in general, grocery store produce has higher nutritional content than garden produce, although this only holds statistical significance for the nutrients manganese and phosphorous. In addition, while averages for nutrient content were higher for store produce, garden produce appeared to have a better taste profile that was statistically significant and was more consistently ripened as well.

Tomatoes were chosen for this study due to their range and popularity, however, future research on this topic should perhaps focus on comparing not just tomatoes, but different types of produce as well, such as cucumbers, peppers, or leafy greens. Additionally, while this study focused on nutrition and food security, it would be important to better understand the demographics of Sioux Falls gardeners and their access to fresh produce. Community gardening and food security are often associated with individuals of low income and poor access to fresh produce, but the respondents to this study appeared to be highly educated and likely wealthier than others.

More specifically, for the case of Sioux Falls, including more questions and a larger number of respondents may lead to greater opportunity for analysis. Future research could also benefit from a greater variety of respondents, not just community gardeners, but private urban gardens in general, and perhaps those who do not garden such as their family members. It would also be interesting to see the results from comparing nutritional content and taste from exact varieties of tomatoes between stores and gardens. Lastly, it would be both intriguing and beneficial to see this method used to compare perceptions of food security and the nutritional quality of grocery store and garden produce from different cities across the United States and other countries.

Concerns about health and nutritional food have emerged across the local, state, and national level. Thus, a case study approach was used to examine how Sioux Falls community gardens can mitigate issues related to food insecurity. The primary goal of this study was to examine the role of food insecurity as it relates to health and community gardens and gardeners in Sioux Falls, SD. The results of this research indicate that gardening had a positive impact on food security, as gardening led to greater access to

produce, greater consumption of produce and overall improved diets from the perspective of gardeners. The results of this research also indicate that garden produce was generally sweeter, with similar nutrient levels; thus, produce is not necessarily healthier, but it is more accessible and presumably tastier from gardens. Furthermore, high accessibility and tastiness in garden produce likely leads to higher consumption and overall improved food security. This aligns with the survey results where gardeners acknowledged eating more produce and having better access to produce due to gardening.

APPENDIX A

Survey Responses by Question Number

Question 1: How many years have you been gardening?		
Less than a year	6	10.0%
1 to 2 years	3	5.0%
3 to 5 years	13	21.7%
5 to 10 years	10	16.7%
More than 10 years	28	46.7%

Question 2: Please indicate the highest level of education completed		
High School	4	6.7%
Some College	7	11.7%
Professional diploma/degree	6	10.0%
Bachelor's degree	23	38.3%
Some Graduate classes	5	8.3%
Graduate Degree	15	25.0%

Question 3: What is the primary reason you began gardening?		
Exercise/Physical Activity	2	3.3%
Improve diet	12	20.0%
To lower grocery bill	7	11.7%
Low access to fresh fruits and vegetables	9	15.0%
Improve sense of community	0	0.0%
Reconnect with nature	9	15.0%
Other	21	35.0%

Question 4: Do you feel you have better access to fresh fruits and veggies because you garden?		
Yes	56	93.3%
No	4	6.7%

Question 5: Does your diet contain more nutritious food because you garden?		
Yes	53	89.8%
No	6	10.2%

APPENDIX A (CONTINUED)

Question 6: Do you eat more fresh fruits and vegetables since you began gardening?		
Yes	49	81.7%
No	11	18.3%

Question 7: If yes to Question 6, do you eat more fresh fruits and vegetables all year long?		
Yes	37	74.0%
No	13	26.0%

Question 8: How many servings of fruits and vegetables do you eat per day?(1 serving is equivalent to 1/2 cup of green beans or 1/2 a medium apple)		
Less than one	1	1.7%
1 to 3	21	35.0%
3 to 5	22	36.7%
5 or more	16	26.7%

Question 9: Other than your grocery store, where do you obtain your fresh fruits and vegetables?		
Grocery Store	46	76.6%
Farmers Market and Grocery Store	10	16.7%
Farmers Market	3	5.0%
Co Op	1	1.7%

Question 10: Do you eat more fruits and vegetables from your garden or from stores		
Garden	23	23.0%
Store	33	32.0%
From another source	4	4.0%

APPENDIX A (CONTINUED)

Question 11: If you eat more fruits and vegetables from you garden than other sources, what is the main reason? (Check all that apply)		
Its easily available	21	21.6%
It's more delicious	26	26.8%
If I don't eat it, it will go to waste	14	14.4%
Its more affordable	19	19.6%
Health reasons	13	13.4%
Other	4	4.1%

Question 12: Do you grow more food than you can use?		
Yes	42	70.0%
No	18	30.0%

Question 13: if yes to Question 12, what do you do with the surplus? (Check all that apply)		
Donate	6	11.4%
Distribute to friends and family	25	56.8%
Sell	0	0.0%
Can	6	13.6%
Other	8	18.2%

APPENDIX B

Free Text Response Categorization for the Primary Reason Gardeners Began Gardening

4	**Access***	Own access to fresh produce
		to grow own produce
		Access to organic vegetables
		wanted specific items not easily found in stores
1	**Canning**	For canned tomatoes
1	**Family/Nature**	Spend time together with family in nature
1	**Give Away**	give it away
9	**Hobby**	Hobby
		I enjoy watching the garden produce grow and eating the produce
		I love it.
		Enjoy it
		Interest
		Hobby
		I enjoy it
		To grow, eat and can organic vegetables
		I enjoy gardening, growing things
1	**Other**	All of the above
1	**Relaxation**	Personal time/Relaxation
3	**Taste**	Taste better out of the garden
		love the taste of vegetables that have been vine ripened
		I like homegrown foods and for pleasure

* Highlighted items indicate responses added with “Access” responses from Figure 19

APPENDIX C

Coding of Free Text Response Where Gardeners Obtain Their Fresh Fruits and Vegetables

CSA	CSA	**1**
Farmers Market	Market	
Farmers Market	farmers market	
Farmer's Market	At farmer's market	**3**
Grocery Store/Farmer's Market	Farmer's Market & Grocery Store	
Grocery Store/Farmer's Market	Farmer's Market, Co-Op, Grocery Store	
Grocery Store/Farmer's Market	Farmers market, grocery store	
Grocery Store/Farmer's Market	Local farmers, groceries stores	
Grocery Store/Farmer's Market	Farmers market, supermarket	
Grocery Store/Farmer's Market	Farmers Market and Grocery store	
Grocery Store/Farmer's Market	Farmers Market & Costco	
Grocery Store/Farmer's Market	Farmer market, grocery stores.	
Grocery Store/Farmer's Market	Grocery store, farmers market	**9**
Grocery Store	local grocery stores, relatives	
Grocery Store	Grocery store	
Grocery Store	Grocery stores and Costco	
Grocery Store	Costco	
Grocery Store	grocery store	
Grocery Store	wholesale companies, grocery store	
Grocery Store	grocery store	
Grocery Store	Grocery store	
Grocery Store	store	
Grocery Store	store	
Grocery Store	grocery stores	
Grocery Store	grocery store	
Grocery Store	Grocery store	
Grocery Store	Costco	
Grocery Store	grocery store	
Grocery Store	grocery store	
Grocery Store	Costco, Sam's, Fareway	
Grocery Store	grocery store	
Grocery Store	Grocery stores	
Grocery Store	Grocery store	

APPENDIX C (CONTINUED)

Grocery Store	grocery store	
Grocery Store	grocery store	
Grocery Store	Grocery store	
Grocery Store	Store	
Grocery Store	Grocery Store	
Grocery Store	Grocery store	
Grocery Store	grocery store	
Grocery Store	supermarket	
Grocery Store	Sam's Club	
Grocery Store	Hy-Vee, Walmart, Aldi, Fare-way	
Grocery Store	grocery store	
Grocery Store	grocery store	
Grocery Store	Fairway Stores	
Grocery Store	organic at stores	
Grocery Store	store	
Grocery Store	Retail Grocery	
Grocery Store	Grocery stores	
Grocery Store	Walmart	
Grocery Store	The store	
Grocery Store	Grocery store	
Grocery Store	Hy-Vee, or the Co-op	
Grocery Store	Grocery store	
Grocery Store	Grocery Store.	
Grocery Store	The Co-Op	
Grocery Store	Grocery Store	
Grocery Store	Grocery Store	
Grocery Store	Grocery store	**47**

APPENDIX D

Garden and Store Comparisons, Along with the Variety of Tomato Obtained From Each Location

First Sampling Period			Second Sampling Period		
Set	**Location**	**Type**	**Set**	**Location**	**Type**
1	Memorial	Roma	**1**	Memorial	Cherry
	Hy-Vee-Marion	Roma		Hy-Vee-Marion	Cherry
2	E 10th Garden	Roma	**2**	E 10th Garden	Roma
	Hy-Vee - E 10th St	Roma		Hy-Vee - E 10th St	Roma
3	1st Premier Bank	Better Boy	**3**	1st Premier Bank	Heirloom
	Sunshine	Regular/On Vine		Sunshine	Greenhouse/Hydroponic
4	Spirit of Joy Church	Unknown	**4**	Spirit of Joy Church	Roma
	Hy-Vee - E 57th St	Regular/On Vine		Hy-Vee - E 57th St	Roma
5	Leaders park	Regular/On Vine	**5**	Leaders park	Unknown
	Aldi	Unknown		Aldi	Beefsteak
6	Falls Park	Regular/On Vine	**6**	Falls Park	Regular/On Vine
	Franklin	Unknown		Franklin	Greenhouse/Hydroponic
7	Lincoln Elementary	Whopper	**7**	Lincoln Elementary	Cherry
	Hy-Vee - Kiwanis	Beefsteak		Hy-Vee - Kiwanis	Cherry
8	Southern Hills Church	Celebrity	**8**	Southern Hills Church	Unknown
	Fareway	Regular/On Vine		Fareway	Regular/On Vine
9	University Center	Unknown	**9**	University Center	Unknown
	Walmart 60th St N	Regular/On Vine		Walmart 60th St N	Regular/On Vine
			10	Avera	Unknown
				Hy-Vee - Minnesota	Regular/On Vine

*For each sample pair, gardens are listed first

APPENDIX E

Sugar Content and Ripeness Data

			First Sampling Period			Second Sampling Period		
Set	Location	Type	Test	Firmness	Brix	Test	Firmness	Brix
1	Memorial	Garden	1	2.64	5.10	1	2.45	6.30
			2	2.29	5.20	2	2.10	6.10
			3	2.73	5.20	3	2.01	6.30
	Hy-Vee Marion	Store	1	2.74	4.10	1	2.43	7.30
			2	4.96	5.10	2	2.72	6.70
			3	4.23	5.00	3	2.97	6.70
2	E 10th Garden	Garden	1	2.20	5.50	1	2.37	5.20
			2	3.23	5.60	2	3.05	5.20
			3	3.83	5.50	3	3.04	5.50
	E 10th Hy-Vee	Store	1	3.80	5.30	1	3.22	4.00
			2	3.71	5.10	2	3.93	3.70
			3	3.86	5.30	3	2.97	4.30
3	1st Premier Bank	Garden	1	2.77	6.10	1	2.09	7.30
			2	3.31	6.70	2	2.36	6.30
			3	1.86	6.40	3	1.62	4.80
	Sunshine	Store	1	2.86	4.80	1	1.84	3.70
			2	2.80	4.80	2	1.96	3.80
			3	3.94	4.50	3	2.99	3.70
4	Spirit of Joy	Garden	1	3.77	8.90	1	2.98	4.80
			2	3.14	8.10	2	3.59	3.90
			3	2.64	7.00	3	3.40	4.30
	E 57th Hy-Vee	Store	1	4.86	4.40	1	4.47	4.70
			2	4.50	4.60	2	4.61	4.80
			3	3.54	4.80	3	5.71	4.60
5	Leaders Park	Garden	1	2.77	5.60	1	2.38	5.60
			2	1.97	5.40	2	2.99	5.20
			3	2.10	5.70	3	3.09	6.20
	Aldi	Store	1	1.88	3.70	1	2.94	3.90
			2	0.81	3.50	2	4.21	4.40
			3	1.50	4.10	3	2.95	4.00

APPENDIX E (CONTINUED)

			First Sampling Period			Second Sampling Period		
Set	Location	Type	Test	Firmness	Brix	Test	Firmness	Brix
6	Falls Park	Garden	1	2.60	4.00	1	2.45	6.30
			2	1.33	3.70	2	2.10	6.10
			3	2.76	5.60	3	2.01	6.30
	Franklin	Store	1	2.65	3.60	1	2.43	7.30
			2	2.42	3.90	2	2.72	6.70
			3	2.36	3.20	3	2.97	6.70
7	Lincoln Elem	Garden	1	3.17	4.50	1	2.37	5.20
			2	3.31	4.90	2	3.05	5.20
			3	2.93	5.00	3	3.04	5.50
	Hy-Vee Kiwanis	Store	1	2.69	3.10	1	3.22	4.00
			2	1.81	3.40	2	3.93	3.70
			3	1.76	3.50	3	2.97	4.30
8	Southern Hills	Garden	1	2.49	6.50	1	2.09	7.30
			2	2.55	5.30	2	2.36	6.30
			3	2.45	5.00	3	1.62	4.80
	Fareway	Store	1	4.20	5.40	1	1.84	3.70
			2	3.38	5.20	2	1.96	3.80
			3	2.51	4.80	3	2.99	3.70
9	University Center	Garden	1	1.77	5.40	1	2.98	4.80
			2	2.36	5.10	2	3.59	3.90
			3	2.08	5.20	3	3.40	4.30
	Walmart 60th St N	Store	1	2.75	4.50	1	4.47	4.70
			2	2.25	4.20	2	4.61	4.80
			3	1.72	4.20	3	5.71	4.60
10	Avera	Garden	1	-	-	1	2.09	7.10
			2	-	-	2	1.91	6.40
			3	-	-	3	1.07	6.30
	Hy-Vee Minnesota	Store	1	-	-	1	2.43	3.10
			2	-	-	2	1.16	3.30
			3	-	-	3	2.20	3.00

APPENDIX F

ICP-OES Data

First Sampling Period									
Set	**Location**	**Type**	**P %**	**K %**	**Zn (ppm)**	**Fe (ppm)**	**Mn (ppm)**	**Cu (ppm)**	**Ca %**
1	Memorial	Garden	0.303	3.30	11.8	22.5	4.1	12.9	0.09
	Hy-Vee-Marion	Store	0.390	3.42	16.2	37.3	9.7	9.2	0.14
2	E 10th Garden	Garden	0.281	3.47	13.4	30.1	4.6	8.0	0.10
	Hy-Vee - E 10th St	Store	0.322	3.25	14.9	43.4	4.9	9.6	0.09
3	1st Premier Bank	Garden	0.370	3.28	14.9	22.3	3.3	8.9	0.10
	Sunshine	Store	0.320	3.39	13.5	30.5	3.6	5.1	0.15
4	Spirit of Joy Church	Garden	0.387	3.53	19.6	33.6	4.8	11.5	0.04
	Hy-Vee - E 57th St	Store	0.479	3.77	14.0	39.2	13.0	9.8	0.06
5	Leaders park	Garden	0.333	3.68	13.4	42.8	5.5	9.6	0.09
	Aldi	Store	0.430	4.03	16.2	46.1	15.4	8.1	0.17
6	Falls Park	Garden	0.316	3.16	12.8	30.6	4.6	8.8	0.13
	Franklin	Store	0.303	3.47	16.5	37.8	5.7	18.2	0.15
7	Lincoln Elementary	Garden	0.299	3.11	12.6	28.1	4.9	9.0	0.13
	Hy-Vee - Kiwanis	Store	0.406	4.23	15.5	33.9	7.0	8.5	0.19
8	Southern Hills Church	Garden	0.245	3.44	12.0	30.1	5.0	8.5	0.14
	Fareway	Store	0.407	3.17	19.8	43.9	5.8	11.3	0.11
9	University Center	Garden	0.296	3.31	14.8	34.2	4.0	13.8	0.19
	Walmart 60th St N	Store	0.427	4.71	17.7	32.8	13.0	11.5	0.19

APPENDIX F (CONTINUED)

Second Sampling Period									
Set	**Location**	**Type**	**P %**	**K %**	**Zn (ppm)**	**Fe (ppm)**	**Mn (ppm)**	**Cu (ppm)**	**Ca %**
1	Memorial	Garden	0.275	2.93	12.5	29.0	2.4	13.5	0.09
	Hy-Vee-Marion	Store	0.345	3.81	13.1	37.9	5.5	9.9	0.08
2	E 10th Garden	Garden	0.304	3.62	13.6	34.6	4.8	9.2	0.12
	Hy-Vee - E 10th St	Store	0.376	4.20	18.3	37.1	6.8	12.3	0.11
3	1st Premier Bank	Garden	0.307	3.39	13.0	28.4	4.4	10.0	0.14
	Sunshine	Store	0.460	4.13	24.1	45.0	15.6	10.4	0.16
4	Spirit of Joy Church	Garden	0.288	3.36	13.2	21.9	5.7	13.7	0.10
	Hy-Vee - E 57th St	Store	0.290	3.15	13.1	43.7	6.3	22.4	0.13
5	Leaders park	Garden	0.254	3.46	11.9	33.8	6.5	9.8	0.17
	Aldi	Store	0.385	3.25	11.2	27.9	10.6	5.8	0.12
6	Falls Park	Garden	0.440	3.57	15.3	30.8	5.0	16.2	0.08
	Franklin	Store	0.379	3.17	12.5	21.7	6.4	6.6	0.13
7	Lincoln Elementary	Garden	0.378	3.51	17.5	33.5	4.3	11.6	0.09
	Hy-Vee - Kiwanis	Store	0.377	3.89	14.6	35.9	3.9	5.5	0.09
8	Southern Hills Church	Garden	0.449	3.63	24.4	42.0	4.7	8.4	0.05
	Fareway	Store	0.434	3.39	16.9	50.8	9.2	12.6	0.20
9	University Center	Garden	0.290	2.76	17.0	31.2	4.1	6.9	0.13
	Walmart 60th St N	Store	0.361	3.19	11.6	25.0	6.2	8.0	0.21
10	Avera	Garden	0.258	3.15	17.8	42.0	4.9	9.6	0.15
	Hy-Vee - Minnesota	Store	0.548	3.85	11.5	31.7	13.4	8.2	0.13

REFERENCES

Agriculture Solutions. 2015. Digital Fruit Firmness Tester, Penetrometer. Available at https://www.agriculturesolutions.com/products/crop-soil-and-water-testing/fruit-firmness-testers/digital-fruit-firmness-tester-penetrometer-general-fruit-detail (last accessed 6 December 2017).

Alaimo, K., Packnett, E., Miles, R.A., & Kruger, D.J. 2008. Fruit and Vegetable Intake among Urban Community Gardeners. *Journal of Nutrition Education and Behavior*. 40. 94-101.

Altman, M., Cahill Holland, J., Lundeen, D., Kolko, R., Stein, R., Saelens, B., Welch, R., Perri, M., Spechtman, K., Epstein, L., and Wilfley, D, 2015. Reduction in Food Away from Home Is Associated with Improved Child Relative Weight and Body Composition Outcomes and This Relation Is Mediated by Changes in Diet Quality. *Journal of the Academy of Nutrition & Dietetics*. 115. 1400-1407.

Andreatta, S. 2015. Through the Generations: Victory Gardens for Tomorrow's Tables. *Culture, Agriculture, Food and Environment*. 37. 38-46.

Blair, D., Giesecke, C., and Sherman, S. 1991. A dietary, social and economic evaluation of the Philadelphia urban gardening project. *The Journal of Nutrition Education.* 23. 161–167.

Broadway, M. 2009. Growing Urban Agriculture in North American Cities: The Example of Milwaukee. *Focus on Geography*. 52. 23-30.

Brown, K., and Carter, A. 2003. Urban Agriculture and Community Food Security in the United States: Farming from the City Center to the Urban Fringe. Community Food Security Coalition.

Brown, M.E., J.M. Antle, P. Backlund, E.R. Carr, W.E. Easterling, M.K. Walsh, C. Ammann, W. Attavanich, C.B. Barrett, M.F. Bellemare, V. Dancheck, C. Funk, K. Grace, J.S.I. Ingram, H. Jiang, H. Maletta, T. Mata, A. Murray, M. Ngugi, D. Ojima, B. O'Neill, and C. Tebaldi. 2015. Climate Change, Global Food Security, and the U.S. Food System. USDA U.S. Global Change Research Program.

Budiansky, S. 2002. How affluence could be good for the environment. *Nature*. 416. 581-581.

Castro, D.C., Samuels, M., & Harman, A.E. 2013. Growing Healthy Kids: A Community Garden–Based Obesity Prevention Program: A Community Garden–Based Obesity Prevention Program. *American Journal of Preventive Medicine*. 44. S193-S199.

CDC. 2002-2009. Behavioral Risk Factor Surveillance System Survey Data. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

CDC. 2007-2010. Behavioral Risk Factor Surveillance System Survey Data. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

CDC. 2012. Behavioral Risk Factor Surveillance System Survey Data. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Chappell, M.J., LaValle, L.A., 2011. Food security and biodiversity: can we have both? An agro ecological analysis. *Agriculture and Human Values.* 28. 3–26.

City of Sioux Falls. 2015. Community Garden Locations. Available at http://www.siouxfalls.org/parks/parks/community-gardens/locations.aspx (last accessed 3 January 2016).

City of Sioux Falls. 2017. GIS Open Data. gisopendata.siouxfalls.org (last accessed 15 September 2017).

Cohen, L., Larijani, S., Aboelata, M., and Mikkelsen, L. 2004. *Cultivating Common Ground: Linking Health and Sustainable Agriculture*. Oakland, CA: Prevention Institute.

Colasanti, K.J.A., Hamm, M.W., Litjens, C.M. 2012. The City as an "Agricultural Powerhouse"? Perspectives on Expanding Urban Agriculture from Detroit, Michigan. *Urban Geography.* 33. 348-369.

Coleman-Jensen, A., Rabbitt, M.P., Gregory, C.A., and Singh, A. 2017. Household Food Security in the United States in 2016, *U.S. Department of Agriculture, Economic Research Service*. 1-36.

Community Health Status Report. 2012. Sioux Falls Community Health Status. Available at: http://livewellsiouxfalls.org/images/uploads/main/Community_Health_Report_Final-030813.pdf. 1-115.

Community Health Status Report. 2016. Sioux Falls Community Health Status. Available at: http://livewellsiouxfalls.org/images/uploads/main/2016_CHNA_Report_Final.pdf. 1-114.

Corrigan, M.P. 2011. Growing what you eat: developing community gardens in Baltimore, Maryland. *Applied Geography*. 31. 1232–1241.

Department of Economic and Social Affairs. 2017. Key Findings and Advance Tables. In *World Population Prospects - The 2017 Revision.* 1-46.

Dixon, J., Donati, K., Pike, L., and Hattersley, L. 2009. Functional foods and urban agriculture: two responses to climate change-related food insecurity. *New South Wales Public Health Bulletin.* 20. 14–18.

Drewnowski, A. 2004. Obesity and the Food Environment: Dietary Energy Density and Diet Cost. *American Journal of Preventive Medicine*. 27. 154-162.

Drewnowski, A. 2005. Concept of a nutritious food: toward a nutrient density score. *American Journal of Clinical Nutrition*. 82. 721–732.

ERS. 2017. U.S. Department of Agriculture (USDA). Food Research Atlas. Available at: https://www.ers.usda.gov/data-products/food-access-research-atlas/ (last accessed 15 September 2017).

Feeding America. 2015. Food Security in the United States. Available at http://map.feedingamerica.org/ (last accessed 3 January 2016).

FAO. 1996. *The Rome Declaration on World Food Security and World Food Summit Plan of Action*. 1-7.

FAO. 2008. An Introduction to the Basic Concepts of Food Security. *Food Security Information for Action*. 1-3.

Fox, T. J. 2011. *Urban Farming*. Irvine, CA BowTie Press. 1-416.

Francis M., Cashdan, L., Paxson, L. 1994. The Healing Dimensions of People–Plant Relations: Proceedings of a Research Symposium: March 24–27, 1994. Center for Design Research, Department of Environmental Design, University of California.

Frison, E. A., Smith, I.F., Johns, T., Cherfas, J., Eyzaguirre, P.B. 2006. Agricultural biodiversity, nutrition, and health: Making a difference to hunger and nutrition in the developing world. *Food and Nutrition Bulletin* 27. 167-179.

Graham, H., Beall, D.L., Lussier, M., McLaughlin, P., and Zidenberg-Cherr S. 2005. Use of school gardens in academic instruction. *Journal of Nutrition Education and Behavior.* 37. 147–151.

Goreham, G.A., and Stofferahn, C.W. 2001. Enhancing Local/Regional Food Systems for Sustainable Development. North Dakota Extension and South Dakota Extension Service. 1-150.

Guitart, D., Pickering, C., and Byrne J. 2012. Past results and future directions in urban community gardens research. *Urban Forestry and Urban Greening*. 11. 364-373.

Hanna, A., and Oh, P. 2000. Rethinking urban poverty: a look at community gardens. *Bulletin of Science Technology and Society*. 20. 207–216.

HHS. 2005. Dietary Guidelines for Americans. Washington, DC: U.S. Government Printing Office. 1-84.

HHS. 2010. Dietary Guidelines for Americans. Washington, DC: U.S. Government Printing Office. 1-95.

Holland, L. 2004. Diversity and connections in community gardens: a contribution to local sustainability. *Local Environment.* 9. 285–305.

Kingwell, R., Doran-Browne, N., Eckard, R., and Behrendt, R. 2015. Nutrient density as a metric for comparing greenhouse gas emissions from food production. *Climatic Change.* 129. 73-87.

Levi, J., Rayburn, J., Segal, L.M., Martin, A. 2015. The State of Obesity: Better Policies for a Healthier America. *Trust for America's Health.* Available at http://stateofobesity.org/files/stateofobesity2015.pdf (last accessed 3 January 2016).

Lautenschlager, L., & Smith, C. 2007. Understanding gardening and dietary habits among youth garden program participants using the Theory of Planned Behavior. *Appetite.* 49. 122–130.

Lawson, J., and Knox, M. 2002. Weaving the Food Web: Community Food Security in California. Community Food Security Coalition.

Martin, C., Zhang, Y., Tonelli, C., and Petroni, K. 2013. Plants, diet and health. *Annual Review Plant Biology*. 64. 19–46.

Matteson, K., Ascher, J., and Langellotto, G. 2008. Bee richness and abundance in New York City urban gardens. *Annals of the Entomological Society of America.* 101. 140–150.

McClintock, N. 2011. From Industrial Garden to Food Desert: Demarcated Devaluation in the Flatlands of Oakland, California. *Cultivating Food Justice: Race, Class, and Sustainability*. 89-120.

Milligan, C., Gatrell, A., and Bingley, A. 2004. Cultivating health: therapeutic landscapes and older people in Northern England. *Social Science and Medicine.* 58. 1781–1793.

Milwaukee Instruments. 2011. MA871 Digital Brix Refractometer. Available at http://www.milwaukeeinst.com/site/products/products/digital-refractometers/165-products-g-digital-refractometers-g-ma871 (last accessed 6 December 2017).

Morland, K., and Evenson, K. 2009. Obesity Prevalence and the Local Food Environment. *Health and Place*. 15. 491-495.

Mundel, E., and Chapman, G.E. 2010. A decolonizing approach to health promotion in Canada: the case of the Urban Aboriginal Community Kitchen Garden Project. *Health Promotion International.* 25. 166-173.

National Gardening Association. 2014. Food Gardening in the U.S. at the Highest Levels in More Than a Decade According to a Report by the National Garden Association. Garden.org. Available at http://assoc.garden.org/press/press.php?q=show&id=3819&pr=pr_nga (last accessed 3 January 2016).

National Research Council. 1989. Alternative agriculture / Committee on the role of alternative farming methods in modern production agriculture. Washington, DC: National Academy Press. 1-448.

National Research Council. 2010. How Will We Sustainabily Feed Everyone in the Coming Decade and Beyond? In *Understanding the Changing Planet*. 59-66. Washington DC: The National Academy Press. 59-66.

Nguyen, B., Shuval, K., Bertmann, F., and Yaroch, A. 2015. The Supplemental Nutritional Assistance Program, Food Insecurity, Dietary Quality, and Obesity Among U.S. Adults. *American Journal of Public Health*. 105. 1453-1459.

Paarlberg, D. and Paarlberg, P. 2000. *The Agricultural Revolution of the 20th Century*. Ames, IA: Iowa State University Press. 1-154.

Primavesi, L., Caccavelli, G., Ciliberto, A., and Pauze, E. 2015. Nutrieconomic Model Can Facilitate Healthy and Low-cost Food Choices. *Public Health Nutrition*. 18. 827-835.

Pudup, M. 2008. It takes a garden: cultivating citizen-subjects in organized garden projects, *Geoforum.* 39. 1228–1240.

Rhone, A., Ver Ploeg, M., Dicken, C., Williams, R., and Breneman, V. 2017. *Low-Income and Low-Supermarket-Access Census Tracts 2010-2015*, U.S. Department of Agriculture, Economic Research Service. 1-15.

Schmelzkopf, K., 1996. Urban community gardens as contested space. *Geographical Review.* 85. 364–381.

Smithsonian Institution. 2017. Vacant Lot Gardens. Grown from the Past: A Short History of Community Gardening in the United States. Available at https://communityofgardens.si.edu/exhibits/show/historycommunitygardens/vacantlot (Last accessed 29 November 2017).

South Dakota Dashboard. 2018. Obesity. Black Hills Knowledge Network. Available at http://www.southdakotadashboard.org/ (Last accessed 14 January 2018).

South Dakota Department of Health. 2015. School Height & Weight Report Summary 2014-2015 School Year. Available at https://doh.sd.gov/documents/statistics/HeightWeight2014-2015Summary.pdf (last accessed 3 January 2016).

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., and Polasky, S. 2002. Agricultural sustainability and intensive production practices. *Nature.* 418. 671-677.

Timmer. P.C., Falcon, W.P., and Pearson, S.R. 1983. *Food Policy Analysis*. Published for the World Bank. The Johns Hopkins University Press. 1-301.

Treuhaft, S., and Karpyn, A. 2010. The Grocery Gap: Who Has Access to Healthy Food and why it Matters. *PolicyLink.* 1-44.

Twiss, J., Dickinson, J., Duma, S., Kleinman, T., Paulsen, H., and Rilveria, L., 2003. Community gardens: lessons learned from California healthy cities and communities. *American Journal of Public Health.* 93. 1435–1438.

United States Census Bureau. 2013. 2*010 Census Urban Area Facts*.

USDA. 2009. Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences. Report to Congress. Available at https://www.ers.usda.gov/webdocs/publications/42711/12716_ap036_1_.pdf?v=41055. (last accessed 1 January 2016).

USDA. 2015. Know Your Farmer, Know Your Food. Available at http://www.usda.gov/wps/portal/usda/usdahome?navid=KNOWYOURFARMER (Last accessed 16 February 2016).

USDA. 2017. Definitions of Food Security. Available at https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx. (last accessed 27 November 2017).

University of Clemson Cooperative Extension. 2006. Nutrient Density. *Home and Garden Information Center*.

University of Missouri Extension. 2009. “The History of Community Gardening”. *Community Gardening Toolkit.*

Ver Ploeg, M., Nulph, D., and Williams, R. 2011. Mapping Food Deserts in the U.S. *Amber Waves*. 9. 46-49.

Van den Berg, A.W., Marijke, W., and de Vries, S., 2010. Allotment gardening and health: a comparative survey among allotment gardeners and their neighbors without an allotment. *Environmental Health.* 9. 74–87.